Inaudible melodies - visual aspects of music applied to color organs

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Abstract

People have long strived to augment music sensation with visuals. Throughout history there have been many different ways to achieve this, one of them being the color organ. After seeing some of the more ancient color organs, we felt this could also be done in a digital age, so we set off to create a digital color organ of our own. A quest that would lead us through different styles of combining sound and vision, to the foundations of visual and musical theory and eventually to ways of forging the latter two into a work of art.

Contents

Chapter 1

Introduction

In the long run we have found
Silent films are full of sound
Inaudibly free

...

Inaudible melodies
Serve narrational strategies
Unobtrusive tones
Help to notice nothing but the zone
Of visual relevancy

– Jack Johnson [8]

As two students from the University of Twente, with a healthy interest in music, we were immediately interested when we saw a first example of a colour organ during a presentation of the course "Art and Mediatechnology". Captivated by the idea of combining music and visuals, we set off to create a colour organ of our own as a practical assignment for this course.

This article takes you, the reader, on a journey through our thinking process as we investigated the history of visual music, the important theories needed to understand (visual) music and finally to a way of putting it all together and creating an actual modern colour organ, where a digital piano is used together with a computer.

Michel Jansen & Wim Bos

Chapter 2

History of visual music

It has long been thought that there is a link between human senses where it comes to the perception of music and colour. Many artists throughout history have been playing with combinations of music and visuals to achieve an even more intense experience in the form of visual music. This chapter takes a quick look at some of the more interesting examples in the history of visual music, which expired us because of their unique ideas or techniques placed in time.

2.1 Visual Music

2.1.1 Early history

The idea of a connection existing between music and colour appears at least as early as the era of the ancient Greeks. Philosophers, like Aristotle and Pythagoras, already speculated that there must be a correlation between the musical scale and the rainbow spectrum of hues [13]. Renaissance artists, including Leonardo da Vinci and Athanasius Kircher have also been known to experiment with these concepts.

2.1.2 Father Louis Bertrand Castel

Father Louis Bertrand Castel lived in the 1700's and was the inventor the first "Color Organ" with had the name "Clavecin Oculaire". Thomas Wilfred wrote the following in "Light and the Artist" [23] :

[Aristotle:]"May not the harmony and discord of Colours arise from the proportions of the vibrations propagated through the fibres of the optick Nerves into the Brain, as the harmony and discord of sounds arises from the proportions of the vibrations of the Air? For some Colours are agreeable, as those of Gold and Indico, and others disagree." Practically what Aristotle wrote in De Sensu, reflects Père Castel with a glance at his Harpsichord.

Color with sound, music for the eye while the ear listens - color music!

It was the first “color organ” in existence, and the first demonstration given was on December the 21st in the year 1734 in Paris. From Moritz [13] we learn that Castel thought it was something that every householding should have, like the big LCD tv nowadays. The technology was a bit clumsy, and did not even make it to the end of Castel's live. No physical relic of it has survived.

The colormapping used

The colormapping that was used in the “Clavecin Oculaire” was based on the color mapping from Newton, but was a bit different because Castel decided for example that the `C` should be blue, because it simply sounded blue. The following note-to-color translations were present:

Table 2.1: The colormapping that was used in the “Clavecin Oculaire”, ©http://homepage.eircom.net/ musima/visualmusic/visualmusic.htm

B	(dark) violet
Bb	agate
A	violet
Ab	crimson
G	red
F#	orange
F	golden yellow
E	yellow
Eb	olive green
D	green
C#	pale green
C	blue

For more information on what exactly the notes in the left column mean, please read 3.

The technology

From Thomas Wilfred [23] it is learned that only a meager description of the Clavecin Oculaire has survived. The things that are known are the following aspects:

- it has a musical keyboard of five octaves
- when a key was pressed, a colored strip of paper or silk would appear above a black screen

- the first octave represented the pure hues, the next the same hues "one degree lighter", and the fifth octave the highest values

2.1.3 Scriabin

Alexander Scriabin was a composer who lived from 1872-1915 and one of his great works was "Prometheus: Le Poème de feu" (Prometheus: the poem of fire). This piece was written for a complete orchestra accompanied by a instrument that did not exist at that time and what was called a "Clavier à Luce" according to Scriabin's score. The idea was that the "organ" would play the colours that were accompanying the music.

" The lower part is the organ point, the colorus base or background, an atmosphere of light intended to bathe the hall. This lower part moves in whole tones or steps and denotes Scriabin's idea of 'race changes', the spiritual evolution undergone by listeners as they hear the music. The upper part is the active, constantly moving change of colour spots. It indicates a new coloru for each new chord or key. The intensity of the lights follows the dynamics of the music. " [21].

Scriabin used the circle of perfect fifths for binding a color to a key. The way this was done can be seen in figure 2.1 which is taken from the orchestral score of the piece Pormetheus. [21] It is not perfectly clear where the coloring was based on, a few sources note that a friend of his, Rimsky-Korsakov, was a synesthete who percepted other colours. The base-color, for the `C` is red, and is the same as Newton once posed. Maybe the colouring was also influenced by his interest in Theosophy.

2.1.4 Oskar Fischinger

Among the early pioneers in combining film and music was Oskar Fischinger [13]. Born in 1900 in Germany, Fischinger was educated with a scientific-technical training in architectural drafting and tool design, as well as violin and organ building [11] [12]. Oskar Fischinger believed that visual ornaments, as seen in his early 'Studies' films, were the musical notation of the future[5]. In 1947 Fischinger produced 'Motion Painting No. 1'. A film painting on acrylic glass to Bach's Brandenburg Concerto no. 3, which is now recognized to be one of the most important works in the genre. Fischinger also created a color organ, which he named the Luminograph.

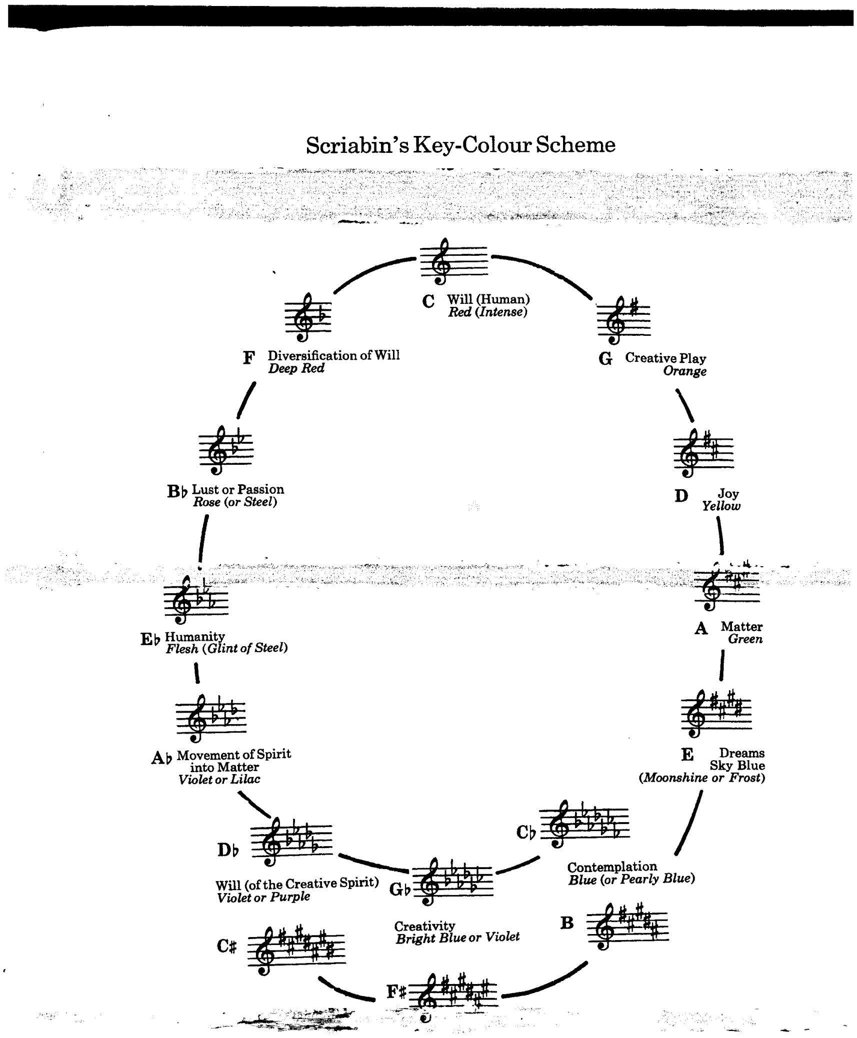

Figure 2.1: The colormapping Scriabin used for his piece "Prometheus: Le Poème de feu", taken from [21]

2.2 Colormappings

There are different ways to map colour to music, a few examples from the website rhytmiclight.com [2] are listed below. On this website there are more possibilities to map color to music presented.

- From pitch to hue (colormappings, as can be found in figure 2.2)
- Dark to deep (the lower the color, the darker the colour)
- From intervals to colors (two notes map together to one colour)

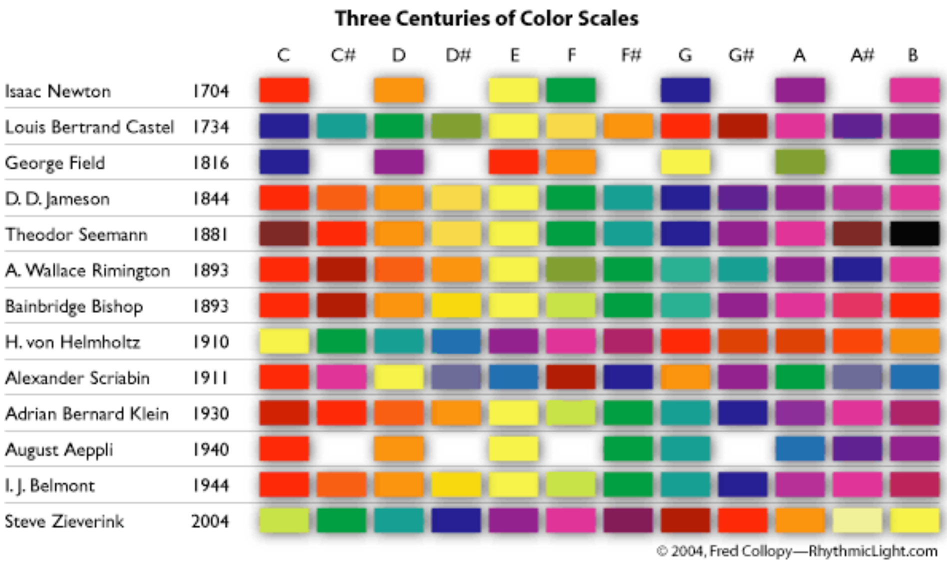

Figure 2.2: The colormappings as found in history, ©Fred Collopy - RhytmicLight.com [2]

Chapter 3

Foundations of music theory

This chapter focuses on the music theory one can use to build a colour organ. This chapter is far from complete, and can therefore not be used as a reference for music theory. If you are looking for a more complete text on music theory, we would like to recommend the website aboutmusictheory.com [17].

This chapter will be a succession of building blocks in music that become larger and larger; the sections build on each other. Tones are used to build scales, scales can be used to indicate intervals, intervals can be used to denote chords. Finally the chords are responsible for the motion in music because of dissonances and consonances, as are the dynamics and the changes in tempo (or even the tempo itself).

3.1 Tones

To create a colour organ that reacts to music, it is necessary to have some knowledge of music to know in what way this music can be translated into visuals. In this project the focus was on constant tone music, wich is the case for piano's. A piano does not have the ability to glide smoothly from one tone to another, but has to go little step by little step.

The keys of a piano or keyboard are arranged into groups of twelve. Such a group is called an "octave", and every group has the same names for the keys and starts at a `C` and ends with a `B`, see 3.1. For distinctive reasons the notes have an addition to uniquely identify that key by adding an octave to it. The lowest note on a piano is therefore often the A0, meaning the A-note in the lowest octave. An interesting fact is that the frequency of the tone doubles every octave, for example, the `A3` has a frequency of 220 Hz, and the `A4` has a frequency of 440 Hz.

There is something called a "central C", and is more or less located in the middle of a normal piano, and is also called the C4. In our colour organ it is possible not to have a piano connected to your computer, because this octave is simulated on the keyboard of the computer.

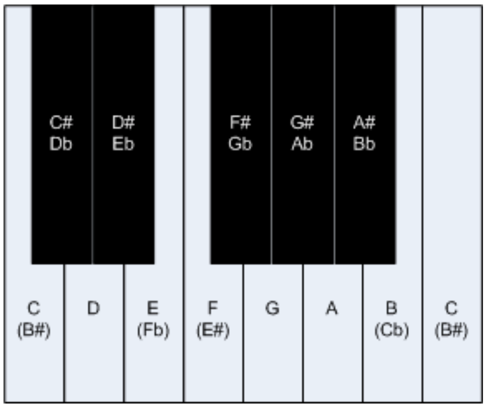

Figure 3.1: an octave with the possible names of every key

3.2 Scales

Every step on a piano is called a half-tone, so the transition from `C` to `C#` is a half-tone, as well as the transition from `E` to `F`. In music theory, a diatonic scale (from the Greek *διατονικος* , meaning "[progressing] through tones") is a seven-note musical scale comprising five whole-tone and two half-tone steps, in which the half tones are maximally separated. Thus between two half-tone steps there are either two or three whole tones, with the pattern repeating at the octave. It can be seen that it is possible to start a scale from every one of the keys on a piano.

As can be seen in 3.1 , the symbol `#` is used for an increase of every half-tone that has not got a name of itself. A `#` stands for "increase the value of the note by a half-tone", and a `b` stands for "decrease the value of the tone by a half-tone". As can be seen, there are 12 different possibilities for a scale on piano. For this report this is the basic knowledge you need to understand the upcoming paragraphs and chapters.

3.3 Tonality

As was presented in the previous section a diatonic scale consists of a series of "distances" between notes. Every "step" of a diatonic scale can be given a Roman Number, starting with the I for the first note of scale, the II for the second and so on. For example, the scale of `F` consists of the notes `F,G,Bb,C,D,E`. Here the `F` is the I, the `G` is the II and so forth until the `E`, which is the VII. As for any other scale, the notes that correspond to the Roman Numbers differ.

There are a lot of ways to play a scale, one of these ways is the way diatonic scale or major scale can be played. Another possibility is the minor scale, where the III, the VI and the VII are a half-tone decreased.

This gives the music a sad feeling. An example of a minor scale consisting entirely on white keys is the scale of "A minor", and consists of the notes `A,B,C,D,E,F,G` whereas the "A major scale consists of the notes `A,B,C#,D,E,F#,G#` . As can be seen the `#` 's are gone, which implies that these three notes are decreased by a half-tone, which is in harmony with the theory of decreasing the IIIth, the VIth and the VIIth note.

There are two variations of the minor scale, one called the melodic minor and the other the harmonic minor. In the melodic minor the VII is NOT decreased, so "A melodic minor" consists of the notes `A,B,C,D,E,F,G#` . In the harmonic minor the VI AND the VII are NOT decreased, so "A harmonic minor" consists of the notes `A,B,C,D,E,F#,G#` . For Blues or Jazz even other scales exist that differ a lot from the scales discussed. We decided not to evaluate these scales in our project.

To get a more entertaining view at tonality, you can have a look at the movie "Tonality.mov" where tonality is visualized. This movie is from www.musanim.com [16] and can be directly found via the Tonality.mov link [1]

3.4 Intervals

With the Roman Numbers freshly in memory as well as the ins and outs of the major and the minor scale, a meaning to an interval can be added. When two notes played on a piano are said to have the interval a "major third" this means that the leftmost of the two is the "I" and the other is the "III". Always take the major scale (also called the diatonic scale) to count the notes. For example, the interval `C-E` is a major third. As the leftmost note is the `C`, the scale considered is the `C` scale, and in the `C` scale (the diatonic or major scale), the `E` corresponds to the III. Another, more complex, example is the interval `C-F#`. Because the leftmost note is a `C`, the scale considered is the`C` scale (major or diatonic). The `F#` is not directly in this scale, but can be seen as an increased IV. Therefore the interval is called an augmented 4th" as can be seen in table 3.4. A list of al the intervals (with their sounds) can be found on the musicintervalstutor website[15].

Hopefully it is now clear what a "perfect fifth" means, the interval I-V. A perfect fifth gives the most consonant harmony (or most stable harmony), except for the perfect octave, which is simply a doubling of the frequency. The perfect fifth is used for a lot of things which will be excluded from this report because they are not needed to understand the rest. The perfect fifth is used by the composer Scriabin, for he based his colours on the "perfect fifth", see also 2.1.3.

If intervals are not yet clear to you, please take a look at the movie "Interval types.mov" for a movie can make intervals far more clear than text

[1] http://one.revver.com/watch/6970

Table 3.1: A listing of all the intervals in music

Minor 2nd	I - descreased II
Major 2nd	I - II
Minor 3d	I - decreased III
Major 3d	I - III
Perfect 4th	I - IV
Augmented 4th	I - increased IV
Perfect 5th	I - V
Minor 6th	I - decreased VI
Major 6th	I - VI
Minor 7th	I - decreased VII
Major 7th	I - VII
Perfect Octave	I - I (one octave higher)

can do, and also in a more entertaining way. The movie was downloaded from www.musanim.com [16] and can be directly found via the Interval types.mov link [2]

3.5 Chords

Chords can be seen as a combination of two or more intervals. To understand a little of chords, a "triad" or "basic chord" will be examined, which can be seen as a combination of two intervals.

This paragraph was constructed from information on this subject at [18] and the earlier sections in this chapter.

A triad consists of notes, a "Root" (I), a "Third" (III) and a "Fifth" (V). For example the "chord" `C-E-G` has as root the `C` (I), as third the `E` (III) and as fifth the `G` (V).

There are four types of triads: major, minor, diminished and augmented. As these terms can be found in the table in the section on intervals, we maybe can make something of this by simply examining possible intervals.

The Major Triad is the "normal case", where we have two intervals. The first interval is the "major third" (from I to III), and the second interval is the "perfect fifth" (from I to V). An example is the "C-major-chord" which consists of the notes `C-E-G` .

The Minor Triad is a variation where one note differs from the Major Triad. The first interval is the "minor third" (I - decreased III), hence the name minor triad. The second interval is the "perfect fifth" (I-V). An example is the "C-minor-chord" which consists of the notes `C-Eb-G` .

The Diminished Triad is a variation where two notes differ from the Major Triad. Because of terminology it is a bit harder to break this one up in

[2] http://one.revver.com/watch/6974

two intervals. The term “diminished” points out that there are two tones from the original major triad that are decreased, and since the Root implicates the chord, it is the Fifth that will be decreased. Terminology tells us this is the “augmented forth” which does not sound at all as diminishing something. In short, the intervals used are the “minor third” and the “augmented forth”, where the latter can be seen as a “diminished fifth” would this term exist. An example is the “C-diminished-chord” which consists of the notes `C-Eb-Gb` .

The Augmented Triad is a variation where only one note differs from the Major Triad. The term “augmented” hints at the increase of a note, in this case the Fifth. In interval-terminology this is called a “minor sixth” which hints at a decrease. So, the intervals used for the augmented triad are the “major third” and the “diminished sixth”, where the latter can be seen as an “augmented fifth”, would this term exists. An example is the “C-augmented-chord” which consists of the notes `C-E-G#` .

There is a lot more on chords, but that does not fit in the scope of our project. If you are interested in learning more, you could search on the internet for chords and the instrument you would like to play these chords on. All music played can be seen as a progression of chords with a melody that “walks around” those chords.

3.6 Harmony

It is a bit hard to describe all about harmony in just one section of one chapter of this report because it is a bit complex. In this section a few terms will be explained, and a very small example will be given of harmony. It is not necessary for the rest of the report to understand it completely. It is hard to put in words the sound that is experienced, so maybe you could try out some dissonant chords and consonant chords on a piano sometime.

A **consonant chord** is a chord that is easy to listen to, sounds “stable” and does not cause an “uneasy feeling”. This phenomenon can be described by some functions which use the frequency of the notes involved, but that is outside the scope of this document. An example is the C-major chord (`C-E-G`).

A **dissonant chord** is exactly the opposite of a consonant chord, and therefore causes an “uneasy feeling” of the chord, and therefore does not sound “stable”. An example is the C-diminished chord (`C-Eb-Gb`).

The use of dissonant chords causes **tension** in music, which implies a certain movement because every dissonant chord wants to **resolve** in a consonant chord. This way music can get your attention, for music with only consonant chords sounds a bit dull. The way dissonant chords resolve to consonants is outside the scope of this document.

Dissonant chords are built op by intervals; a chord with only consonant

Table 3.2: A list of all the intervals and the accompanying sound; dissonant or not

Minor 2nd	I - descreased II	dissonant
Major 2nd	I - II	dissonant
Minor 3d	I - decreased III	consonant
Major 3d	I - III	consonant
Perfect 4th	I - IV	consonant
Augmented 4th (tritone)	I - increased IV	dissonant
Perfect 5th	I - V	consonant
Minor 6th	I - decreased VI	consonant
Major 6th	I - VI	consonant
Minor 7th	I - decreased VII	dissonant
Major 7th	I - VII	dissonant
Perfect Octave	I - I (one octave higher)	consonant

intervals can be called a consonant chord which sounds more harmonious than a dissonant chord, and does not want to "move" to another chord. To give a bit of a feeling on which of the previous presented intervals are consonant, the table with the intervals is updated with another column. As can be seen a chord with a Major or Minor 7th is dissonant, so it implicates a consonant chord in the near future of the music piece.

Information on dissonance and consonance was taken from the website aboutmusictheory.com [17] .

3.7 Dynamics and Tempo

In music the differences between playing very loud and very soft as well as the transitions between these two extremities are important, for it makes music interesting. In MIDI, which was used for this project, this is called velocity; a higher value meaning the tone was pressed harder. In sheet music there are different ways to write this down. A *p* for piano(or pp for pianissimo, or even ppp) indicates the music has to be played (very) soft, and *f* for forte (or ff for fortissimo, or even fff) indicates the music has to be played loud. Transitions from soft to loud are called crescendo's and are present in sheet music as an < sign where the width indicates the timespam that corresponds to the increase in sound. Transtions the other way around are called decrescendo's and are indicated by a >.
In music it is common to use "accelerando's" (positive accelerations) and "ritenuto's" (negative accelerations) to make the music more interesting.

Building blocks in music are for example measures, which consist of a constant number of counts and are filled with enough pauses or tones to fill it. For more information on dynamics and tempo, please have a look at the section on classical music theory on the website aboutmusictheory.com [17].

Chapter 4

Foundations of visual theory

There are a lot of principles available for the visual part of visual music. This chapter concentrates on the most important principles that can be used to visualise music: colour, position and motion.

4.1 Colour

Colour is without a doubt one of the most important components of visualising music. Colours are a major element in visualising images or compositions[22], and have a way of appealing as directly to human emotions as do musical tones [4]. In order to be able to understand the effects of colours, we must first look at what defines a colour.

4.1.1 Characteristics of colours: colour systems

The need for describing colour mixtures originates from early arts like painting. While in early times, it was important to be able to make any colour from a limit set of paints, it is still important today to be able to accurately describe a colour as a number of parameters. This can be done using colour systems, sometimes called colour spaces[6].

Primary colour-based colour systems: RYB & RGB

The first colour space was based on the belief that there were three basic colours: red, yellow and blue. This system was later revised using the primary colours red, green and blue, and is still used in computer monitors. While RGB is based on human physiology's way of perceiving colour, it isn't entirely accurate.

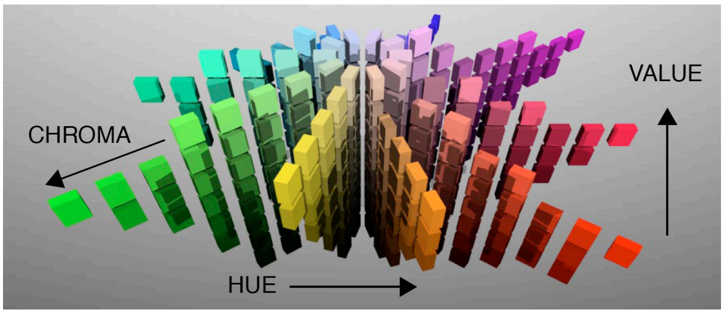

Figure 4.1: The three perceptual attributes of colour

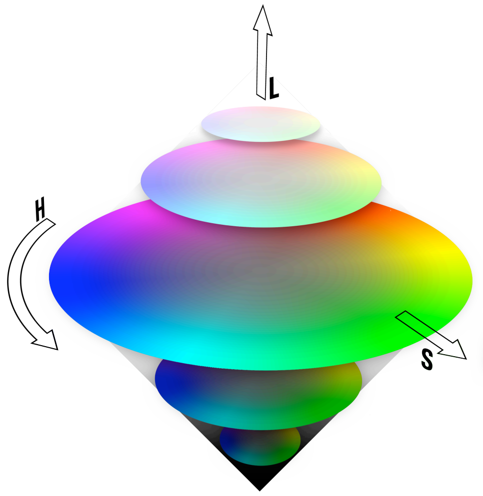

Figure 4.2: A representation of the compents of the HLS colour space.

Perception-based colour systems: HLS & HWK

Another way of looking at colour is by describing them in more human terms. In his Book of Colours, Munsell[14] defined a breakdown of the visual characteristics of colour and the manner in which they interact with one another, which is important in understanding which colours to use in visual music. In Munsell's colour space, any colour is described by three values: hue, value and chroma. These values can be visualised three-dimensionally, like in figure 4.1.

The hue of a colour can be referred to as the specific colour family, such as red, blue, green or yellow. alternatively, hue can be defined as the angle on a colour wheel, or the direction from white, for example in the CIE colour diagram listed in figure 4.3. The value of a colour specifies its lightness or darkness in relation of black or white, often referred to as brightness, brilliance or luminosity. Chroma, often referred to as saturation,

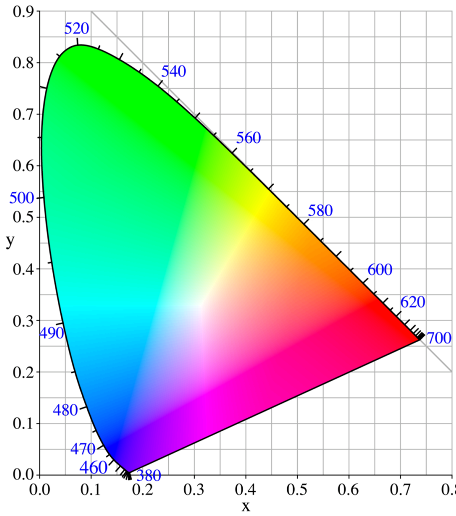

Figure 4.3: The CIE 1931 colour space chromaticity diagram

can be defined as the intensity of the colour or its purity. In the CIE colour diagram in figure 4.3, chroma would be the distance from the white center.

Two well-known colour models using these aspects are HLS (figure 4.2), based on the hue, lightness and saturation and HWK, which describes colour by the components hue, white and black. HWK is similar to HLS as it also specifies the hue in one component, but 'shades' of colour are specified by mixing the proportion of the three components, keeping the sum of the three always one.

4.1.2 Interaction of colours

An important factor in the experience of visualisations, is interaction among colours. Jacobson and Bender state state how the perception of a colour changes depending on its proximally surrounding colours [1]. Colour is therefore context-sensitive. Furthermore, while one viewer's perception of a single colour may be different frome another viewer's perception, the relationships among colours seem to be universal.

Experience of colour is thus not just determined by one, but by many factors, such as the number of colours, the brightness, intensity and size of the entire composition. Therefore, colour experience is best described as an interaction between different dimensions of a coloured composition. Hue contrast, value contrast, block size and area size, but also colour separation and enclosure of colours are examples of these dimensions.

Another form of colour interaction is harmony. A composition of elements coloured in a harmonic fashion is generally perceived as attractive, because there is some similarity in the colours, giving a sense of order and balance[6]. Non-harmonic arrangements are dismissed as either boring or chaotic. Such harmonics are hard to describe when using the RGB colour system used in computer systems, which is based on the amount of red, green and blue light, but become quite apparent when using, for instance, HLS or HWK.

4.1.3 Effects of colour usage

As said before, colours can be a very powerful tool in visualisation. Shifting the hue of a colour towards the red spectrum will cause a sense of warmth. Combinations of colours in a composition can cause an experience of activity (tame-wild or still-vibrant), potency(quiet or loud) and even stress or rest.

4.2 Arrangement

While the relative placement of objects can cause proximity effects like the ones we've seen with colour in the section before, absolute placement of objects on a screen can also be used to enforce the experience of a composition. Variation in location on the vertical or horizontal axis of the screen can be used to visualise some kind of quantitative value. When adding depth to the composition, a third axis is available to have a meaning assigned.

4.3 Motion

A final visual principle important to visualisation is that of motion. The simplest form of motion is that of movement. An example of the use of movement to give a sensation of progression is the Music Animation Machine[16]. By scrolling musical notation from right to left, it creates the sensation of moving from left to right across the music, just as one would when playing a western musical score. Another aspect of motion would be velocity, or speed, meaning the amount of displacement of the composition within a given time. Of course, any of these aspects can be varied over time. By modifying the shape of the motion curve, smooth, overshot or wiggly motion effects can be achieved, resulting in perceptions similar to real-world situations [19].

Chapter 5

Creating a colour organ

In the previous chapters the information about the history of visual music and the most important aspects of musical and visual theories necessary for creating a colour organ were presented. A colour organ is essentially a link between the musical and visual aspects of music and this chapter will deal with how this mapping was done in our case. We will use music as a reference point, since we are interested in generating visuals to match music, not the other way around. Finally, we will explain how we implemented these mappings in a working color organ application.

5.1 Mapping music to visuals

5.1.1 Tones and colour

Tones are the most basic building blocks of music in much the same way colour can be seen as the most basic component in any graphical composition. Both tone and color differences are a direct representation of changes in the frequency in either sound or light. For people with the rare condition of synesthaesia, tone and color are actually linked together in their brains.[7] We therefore deemed it logical to map tone to colour in our colour organ. Since hue is what defines a colour in terms of its frequency, this is the basis of our mapping.

If the music sounds in harmony, we want the colours to be harmonic as well. Because of the 12 different keys where in music can be played, a mapping to harmonics should be dynamic. We chose for a static mapping, where we used the perfect fifth to map colours to tone. This mapping can be seen in figure 5.1.

By basing the hue of a colour associated with a specific tone, chords, which are compositions of tones, will automatically generate an equivalent visual composition. If the chord is harmonic, the colours will be as well, resulting in a both visually and musically pleasing experience.

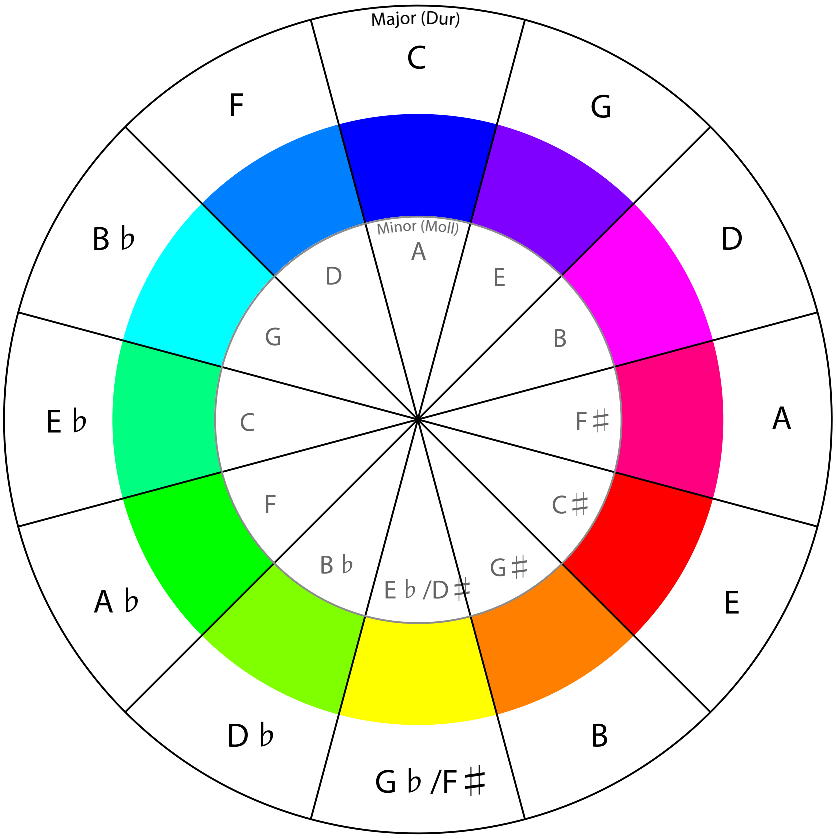

Figure 5.1: The circle of fifths superimposed on a colour wheel. Image partly ©Max Hammond (www.maxhammondphotos.org.uk).

Finally, the luminance of the colour is also dependant on the tone. Higher tones are displayed lighter, having a higher luminance value, while lower tones look darker.

5.1.2 Tones and position

On a piano, every tone is mapped to a key and therefore has its own position. Low tones are on the left, high tones on the right, and we chose to include this in our visualisation by arranging the tones on the screen in the same manner; from left to right.

5.1.3 Dynamics and motion

In order to visualise the velocity of each tone played, we used two visual characteristics: density and speed.

First of all, we modelled the tones as "fountains" spraying coloured particles upwards from their origin at the bottom of the screen. We related the amount of particles to the velocity of the key pressed. Louder tones produce more particles, making the fountain look more dense and adding more of the tone's colour to the scene.

Next, we varied the speed of the particles as they leave their origin to the velocity, symbolising the varying force with which they are thrust upwards. Another result of this is that tones played softly don't reach very high, while loud tones reach the top of the screen.

5.2 Technical implementation

The mappings described in section 5.1 were implemented in a computer program we call 'Inaudible Melodies Colour Organ', which is available under the GNU Public License. This section deals with the technical implementation of this program.

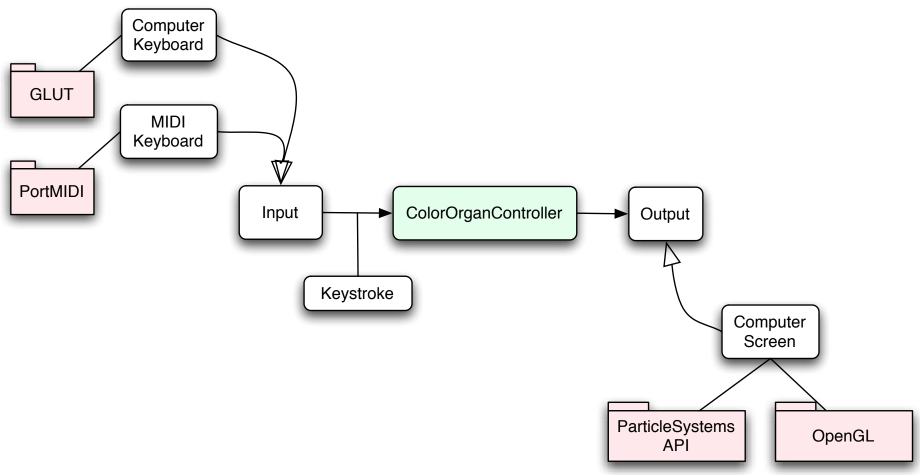

Figure 5.2: Schematic representation of the Color Organ software architecture.

5.2.1 Architecture

Since the application basically maps the music to visuals as described before, it is quite trivial to have the application consist of a musical and a graphical part, linked together by a piece of logic responsible for the mapping. This can be seen in figure 5.2. The part on the left deals with the music (the input), the part on the right is responsible for the visuals. The central component 'ColorOrganController', displayed in green, is where the actual mapping takes place. Since the mapping from music to visuals is essentially one-way, information flows from left to right in the diagram. Finally, the system is surrounded by the libraries it uses, displayed in red in the diagram. By defining the system this way, we developed a pluggable framework which can be extended to use different kinds of input and different kinds of output.

5.2.2 Input

To be able to provide a unified interface for multiple devices, we created an abstract input component. Since we wanted to be able to play both with a MIDI keyboard and without, we created two input components. One providing basic input using a computer keyboard (the organ is played with the keys `A S D F G H J K L` as the white keys on a piano and the keys `W E T Y U O P` as the black keys). This is done using the OpenGL Utility Toolkig (GLUT).

For input using a MIDI keyboard, we provided an input component using the open source library PortMIDI[3].

5.2.3 Output

As mentioned in section 5.1.3, we wanted to visualise tones as "fountains" of sound. We decided to implement this using a particle system. Particle systems are especially suited for producing lively, dynamic visuals[9], which is what we were looking for in this project. Our application uses an open source particle system library[1] to render the tones as particle fountains. The particles in turn, are rendered in a hardware-accelerated way using the open graphics library OpenGL[2].

[1] http://www.particlesystems.org/ [10]
[2] http://www.opengl.org/

Chapter 6

Conclusions and recommendations

The previous chapters have dealt with some important examples from the history of visual music, the important aspects of musical and visual theories and the way in which we combined those aspects into a working digital colour organ. While this already creates a very convincing audio-visual experience, a lot more can be done in this area. This chapter explores some possibilities we were unable to implement due to time limitations.

6.1 Motion and arrangement: focus

Although our colour organ uses some forms of motion and arrangement to enhance musical experience, we feel that a lot more is possible with such a powerful concept. For instance, movement of the camera, zooming, changing the point of view, can create a sense of focus. Aiding the viewer in placing his focus on the visuals and thereby creating an increased sense of involvement.

6.2 Chord detection

Another concept we were unable to include in our colour organ, was that of chord detection. Chords are a very important aspect of music, often forming the baseline of a composition. By using chords to determine, for instance, the background colour (similar to techniques applied by Scriabin), a better visual sensation of the chord as “base” of the composition can be achieved.

6.3 Complex pattern detection

Human beings have a remarkable ability to be able to detect patterns. For instance, if a musical composition is expressed as a set of sentences, each of those sentences can either "climb" up, go down or stay in the same place. We feel this is an area worth exploring. Using data-mining algorithms on the music to find these patterns[20], and turning them into visuals by using motion or arrangement.

6.4 Sustaining tones

From the romantic age on, piano music often uses a damper pedal to be able to sustain tones after they have been pressed. Currently, our colour organ doesn't do anything with sustained tones or pedal usage (the program's behaviour is actually undefined when a pedal is used). Taking into account notes that either die out or are sustained, the amount of particles in each fountain could for instance be varied across time.

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