CONVERTING IMAGES TO MUSIC USING THEIR COLOUR PROPERTIES

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ABSTRACT

Music is associated to colors since ancient years. Different mappings between attributes of sound and images allow the efficient conversion between the two types of media. The proposed method for converting images to music using the concept of chromaticism provides the area of computer music with a parameterized environment for audio-visual presentations. The auditory display of colour images may bring the different ways that a listener perceives a musical piece (because of colour transitions) to light. A design template for chromatic synthesis is described. A short example, based on a graphical digital icon, demonstrates the preliminary results.

1. INTRODUCTION

Recent trends in the area of computer music are related to mappings between images and sound. Usually, this kind of mapping is based on the attributes of images and sounds. But apart from those obvious dimensions (such as frequency, magnitude, size, resolution etc.), there are also some other "hidden" dimensions in a picture or a musical piece, which contain useful information.

The idea of relating colors to music is not new. The ancient Greek philosopher Aristotle unwittingly launched the challenging "*Colour Music*" in his work entitled *De Sensu* [1]. Both Aristotle and Pythagoras had early considered of the existing correlation between musical scale and colors [2]. Relative works to this field are presented in Section 2. What is new here is the association of the attribute *chroma* (the Greek word for colour) with colors and music perception. The present work is based on previous findings [3], [4]. The theoretical approach of the determination of the *chromatic index* is thoroughly described in [3]. *Chroma* and *chromaticism* are two concepts that have redefined several times through the centuries [5]. The important thing here is that chroma is mostly associated with the human perception of sound. Certain chromatic values are considered to generate certain chromatic impressions and feelings to people, the same as certain colour combinations do. The proposal of metrics for chromatic variations, using intervallic parameters (intervals are the real contributors to chromatic values) [3], allows us to map the *chromatic indices* to colour spectrum areas and thus use them for creating sounds. A simple graph of the correlation between colors, music and chroma is shown on Figure 1.

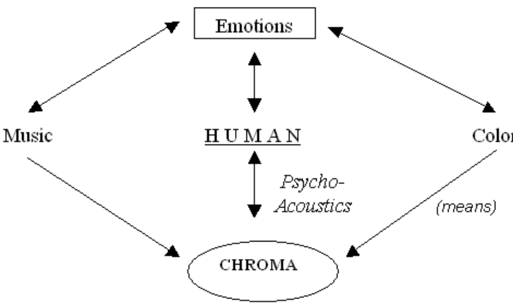


Figure 1. *The correlation between music, colors and chroma.*

The aim of this paper is to provide a preliminary design template for the development of an integrated human-centered audio-visual environment that could compose music using the chromatic aspects of a digitized image. Therefore, the auditory display of the image would consist of an audio representation of how colors are changed through the image. The information on chromatic transitions should be reflected in both sound and image.

After a short report on related projects on this work in Section 2, we introduce the terms of *Chromatic Bricks* and *Chromatic Walls* for music production in Section 3. Section 4, which is the core of this presentation, includes two ways of constructing music melodies with chromatic bricks. In Section 5, a small example of the method is demonstrated by presenting the auditory display of a small computer icon. Finally, in Sections 6 and 7, future directions on this approach are discussed and conclusions are stated.

2. RELATED WORK

Many attempts to compose music from pictures have been done, and likewise the inverse (music-based painting). In general, there is a tendency on music visualizing in several ways. Giannakis & Smith provide a review of auditory-visual associations as these have been investigated in computer music research and related areas [6]. Many visualization techniques take into account several attributes of sound, like density or mass. Such attributes that describe the spectral content of the sound are suitable for calculations, which result to 2D or 3D graphic representations [7].

The synaesthetic association of music to colors has been investigated in several studies [8], [9], [10]. A lot of theories have been deployed about the feelings that colors provoke [11],

[12]. Also, several studies have used color-emotion matching tasks [13], [14] ; matching colors (e.g., red, yellow, blue) to a certain number of emotions (e.g., happiness, sadness, anger). At the same time, all these theories are subjective, and one cannot accept them uncritically.

Image sonification methods to music comprise a wide research area [15]. It is worth mentioning that many composers and artists have used sonification for musical purposes [16].

3. PRODUCING MUSIC USING CHROMATIC BRICKS

3.1. Definitions

Before describing the methods for auditory display of colorful images, some definitions should be apposed.

The concepts of "*chroma*" (which is the fundamental concept that governs this research) and chromaticism have been thoroughly discussed in foregoing papers [3], [4] and by several authors [5], [17]. The basic principle is that the chromatic perception of music is affected very much by the intervallic distances between notes and not the pitches themselves. Indeed, we can estimate **how much chromatic** a musical scale or a melody is by using the *chromatic index* χ [3]. This certain variable is the basic component for creating music from images in the present paper.

We invented the term '*chromatic bricks*' in order to describe the units with which a complete music piece can be created from colors. The composer places colorful bricks (just as a bricklayer), which constitute as a whole the *chromatic wall* (Figure 2). A chromatic brick is to all intents an oblong (filled with a specific colour) that represents a particular musical phrase (a sequence of notes of the melody). Each brick contains the following information: its colour corresponds to a χi value ($1 \leq \chi i \leq 2.2$), which is translated to certain emotions; and its length, which defines the time of the particular musical phrase. In the present paper, durations are considered as length ratios between bricks and not as absolute timings. All the bricks as a whole (that is the chromatic wall) represent the entire melody.

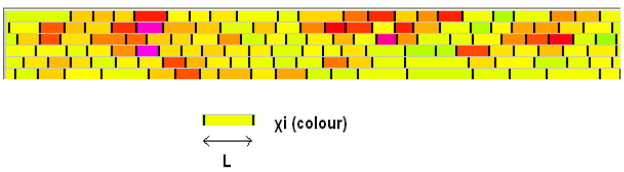


Figure 2. *A Chromatic Wall consists of chromatic bricks with length L and a chromatic value χ_i, which corresponds to a certain colour hue.*

3.2. Mapping Colors to Music

Mapping addresses how the perceptual aspects of images and sounds can be connected and used to influence each other. Figure 3 shows the mapping matrix of this project. The connected elements affect each other in synthesis, or analysis of music. The illustration is a reduced version of the mapping matrix with all possible connections that is presented in [18]. Dotted lines represent the relations that are ignored in this paper.

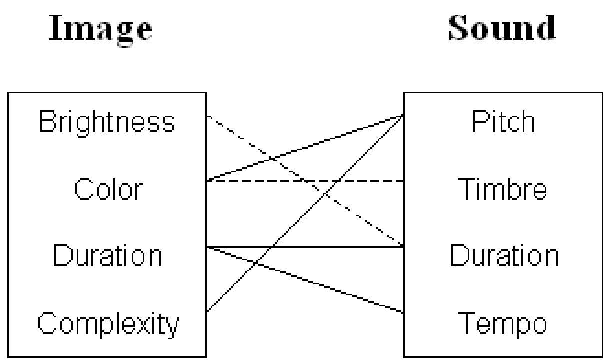


Figure 3. *The mapping matrix of chromatic synthesis.*

The conversion from certain colors to music follows the correspondence of colors to chromatic values χi, as it has been presented in [4]. A 12-grade scale of basic colors has been designed (Table 1), starting from the *white* colour (non-chromatic) and ending to *black* colour (the most chromatic). The more chromatic a colour is, the stronger feelings it causes to the audience, and that should be reflected in the generated music.

Color	χ
White	1.0
Sky Blue / Turquoise	1.1
Green	1.2
Yellow / Gold	1.3
Orange	1.4
Red	1.5
Pink	1.6
Blue / Royal Blue	1.7
Purple	1.8
Brown	1.9
Gray	2.0
Black	2.1

Table 1: Color to chromatic values conversion.

4. METHODS

4.1. Algorithmic Production of Melody using Self-Created Bricks

According to this method, the composer has to build the chromatic wall by creating and putting bricks in place by him. The attributes that a brick needs to be comprised of are: chroma χ and duration of (these values are used as input of the algorithm for melody extraction). Previous to the beginning of bricks creation, the composer has to define: which scale shall his piece be written to (in order to define Scale Chroma by Nature χ^0, which corresponds to the fundamental chroma of the melody) by choosing a scale from the Scale Bank [4], the tempo of the piece (in order the melody to be correctly transcribed to staff notation), and the first note of the composition (which is the basis for the calculation of the first brick's chroma). The first user-defined note should constrainedly belong to the chosen scale.

After defining χ^0, tempo and the first note, the first brick (**χ1,d1**) should be created (**χ1** is its chroma value, and **d1** is its duration). Because of the calculations' complexity, the presented algorithm is oriented exclusively towards the χ variable, taking little into consideration the duration factor. Duration is counted in terms of notes values for simplicity. That is: ♩=1, 𝅗𝅥=2 etc. For instance, the brick (1.4 , 0.5) is a segment containing notes with values equal to an eighth (♪) and orange as its colour. Data modulation, so as real-time durations (in ms) is accepted, is under consideration for future research.

Chromatic synthesis with musical bricks uses the reverse method of chromatic analysis [3]. However there is an important issue here: although a musical piece is analyzed into one and only chromatic graph, a chromatic representation could result to different melodic sequences, which can be equally perceived in terms of feelings. For this preliminary proposal, 10 basic rules are used from the big list of rules for chromatic analysis with MEL-IRIS [4]. These rules are related to the use of notes that do not belong to the chosen scale, and therefore cause the notion of chromaticism (Table 2).

Rule	Intervals	χ transition	Constraints
1	Chromatic semitones	*1.01	-
2	Chromatic 3/2-tone	*1.03	-
3	Chromatic quarter-tones	*1.04	-
4	Part of chromatic scale (N notes, N≥3)	*(1+0.01*N)	-
5	Chromatic integer multiples of tone	%1.005	-
6	Chromatic tones	%1.01	-
7	Retraction of chroma	%1.01	$\chi \geq \chi^0$
8	Retraction of chroma (3/2-tone)	%1.015	$\chi \geq \chi^0$
9	Same note repetition	% 1.02	
10	Accepted Scale Intervals	-	-

Table 2: Rules for the chromatic variable's χ transition in the colour space of an image.

On the basis of these rules, we observe that the first four rules concern the χ increment; the next five rules concern the χ decrease, while the last rule is about the same χ value (the brick bears the same colour to the previous brick)[1]. Consequently, it is proper to use the first four rules in case of bricks with greater χ than the previous brick's χ. Likewise, rules 5 – 9 are applied to bricks with less χ than the previous brick's χ. Finally, the last rule is triggered whenever a similar (in terms of colour) brick to the previous one is created.

Let a brick contain *n* musical units[2] *(m1,m2,...,mn)*. Each musical unit is assigned to a chroma value *χmi* (for *i=1,2,...,n*) based on the interval which is created with the previous musical unit (according to the rules of Table 1). The chromatic index of brick *j (χj)* is equal to the average of *χmi (i=1,2,...,n)* of the musical units it contains:

$$\chi_j = \frac{\sum_{i=1}^{n} \chi_{m_i}}{n} \tag{1}$$

However for each χmi (i=1,2,,…,n) stands

$$\chi_{m_i} = f\left(\chi_{m_{i-1}}\right) \tag{2}$$

and more specifically:

$$\chi_{m_i} = \chi_{m_{i-1}} \cdot k_i \tag{3}$$

where

$$k_i = 1 + 0.01 \cdot N_i \tag{4a}$$

$$\left(N_i \in \mathrm{Z}^+ - \{2\}\right)$$

if it is about the rules 1-4, or

$$k_i = \frac{1}{1 + 0.005 \cdot N_i} \tag{4b}$$

$$\left(N_i \in \{1,2,3,4\}\right)$$

if it is about the rules 5-9.
The sum of χmi is equal to:

$$\sum_{i=1}^{n} \chi_{m_i} = \chi_{m_1} + \chi_{m_2} + \ldots + \chi_{m_n} \tag{5}$$

If the newly created brick bears a greater χ value than the previous brick (χj >χj-1) and the chroma value of the last note of the previous brick is λ, then (1) becomes:

$$\chi_j = \frac{\sum_{i=1}^{n} \left[\lambda \cdot \prod_{k=1}^{i} \left(1 + 0.01 \cdot N_k\right) \right]}{n}. \tag{6a}$$

In case of χj<χj-1 (less χ value than the previous brick) equation (1) becomes:

$$\chi_j = \frac{\sum_{i=1}^{n} \left[\frac{\lambda}{\prod_{k=1}^{i} \left(1 + 0.005 \cdot N_k\right)} \right]}{n}. \tag{6b}$$

Xj and λ are known constant values. The algorithm returns n and the Ni factors values.

[1] The table values are evident of psycho-acoustic experiments and have been finally selected because they match well with our colors – music correspondence. Farther analysis of the particular theory disqualifies as necessary in this paper.

[2] The term '*musical units'* is used instead of '*notes'*, because of rule 4, which concerns more than a note. One musical unit is equal to a note for all other rules.

4.2. Selecting Bricks from a Database

The second method for using chromatic bricks produces unique results, and not multiple possible sequences of notes, although it is more restrictive for the user.

According to this method, fixed bricks, which are stored in a database, are used. Obviously, the composer, other users, or even a random brick generator may create too many bricks and thus enrich this database. This method supports two kinds of bricks: *absolute bricks* and *relative bricks*. An absolute brick is defined in a different way from a relative one. Also, different notation is used to represent each of those kinds.

Absolute bricks have two musical elements explicitly defined: notes and their values (they may even contain rests). For example, an absolute brick is (Fig. 4):

{ (G4 , 1) , (C#5 , 1) , (B4 , 0.5) , (A4 , 0.5) }

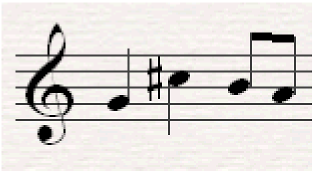


Figure 4. *An absolute brick in notation staff.*

Unlike absolute bricks, relative bricks do not contain information about the absolute notes position, but only the relevant intervals between the notes. Values are also a part of the relative bricks. UDS notation [19] is deemed to be the appropriate notation for relative bricks. The format of a note in a relative brick is thus:

(UDS , #sem , v)

where:
UDS = { U (Up) | D (Down) | S (Same) }
#sem: the number of semitones in the interval which is formed by the note and the previous one (if UDS=S, then #sem=0, else #sem≠0)
v: the value of the note, (♩ = 1).

For example, the relative brick in Figure 5 is denoted as:

{(U , 1 , 1),(D , 2 , 1),(S , 0 , 2),(U , 3 , 0.5),(U , 1.5 , 0.5)}

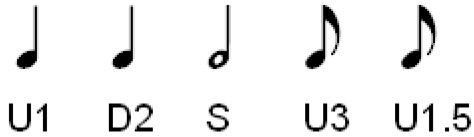


Figure 5. *A relative brick.*

When the user is on composition mode, he/she is able to choose among any of the defined bricks in the database in any order. Each time a new brick is inserted to the chromatic wall, two events happen:

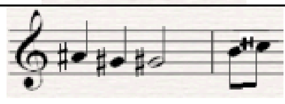
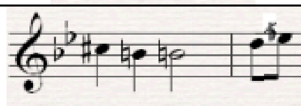
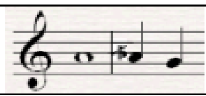
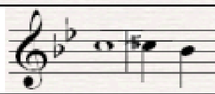
(1) The relative bricks are converted to absolute bricks, since the last note of the last brick that was inserted into the composition allows the conversion. (Notice that this conversion is temporary, and not permanent. Relative bricks remain relative in the database.)

(2) The chromatic average (χ) of each brick is calculated afresh, so as they can graphically appear bearing their colors for the user to choose.

It should be noted here that the chromatic value of each brick cannot be stored de novo in the database, because this calculation requires missing values that the user should first define (the scale with χ^0 and its key). The size that each brick possesses on the screen is determined by the values of the notes it contains. Moreover, at the time the user is prompted to select the first brick of his composition, only the absolute bricks are available. Relative bricks are not available since no previous note exists. Therefore, it makes sense why relative bricks are activated after the first brick's insertion. Figure 6 shows the different representations of an absolute brick and two relative bricks in case of different λ in a different scale.

4.3. Adjusting the Parameters

The compositional technique with fixed bricks from a database (section 4.2) does not appear to have any parameterization problems. However, the real-time synthesis of melodies with user's newly created bricks (section 4.1) requires a fully parameterized environment in order for desirable results to be

Brick	Alphabet Notation	Staff (λ=1.3, A4, C-major)	G. B. R. * (λ=1.3,A4, C-major)	Staff (λ=1.7,C5, G-minor harmonic)	G. B. R.* (λ=1.7, C5, G-minor harmonic)
Absolute	{(G4, 1), (C#5, 1), (B4, 0.5), (A4, 0.5)}		(χ=1,2885) R=226,G=255,B=0		(χ=1,6813) R=48,G=0,B=255
Relative 1	{(U, 1, 1), (D, 2, 1), (S, 0, 2), (U, 3, 0.5), (U, 1.5, 0.5)}		(χ=1,3133) R=255,G=238,B=0		(χ=1,6969) R=8,G=0,B=255
Relative 2	{(S, 0,4,), (D,0.5, 1), (D, 1.5, 1)}		(χ=1,3262) R=255,G=222,B=0		(χ=1,734) R=44,G=0,B=212

*Graphical Brick Representation

Figure 6. *Different representations of bricks in different musical compositions. The chromatic index (λ) and the pitch of the previous note, as well as the scale, define the final graphical brick representation. Calculation of R-G-B values is done according to [4].*

extracted. The reason therefore is that a certain brick may lead the algorithm to hundreds of possible melodies (which is absolutely correct, since the mathematic formula rests on the fact that many melodies may result to the same chromatic perception, e.g. several different melodies may cause melancholy). Therefore, the user should be able to limit the amount of results down and improve the quality of his composition by configuring some (mainly musicological) parameters for the composition as a whole or some bricks separately:

- **Duration of the bricks (segments)**: The lengthier a brick is, the greater chromatic transitions[1] can fit in it. A great transition (>0,3) in a small brick should either create too many short (in terms of values) notes, which results in a difficult or impossible to follow melodic sequence. For example, if a transition from 1,3 to 1,9 is to be represented in a brick of one meter 4/4 in length, this could lead to a chromatic progression of 64 semitones (value = ), which is (usually) unacceptable.
- **Amount of Ni factors**: The manifestation of a transition may take place either with few, or with many Ni factors, which means few or many musical units respectively. A very small amount of Ni factors may result to the failure of a transition, while a big amount of Ni factors may lead a small transition to a monotonous and "blabby" melody.
- **Melodic Thresholds**: Melodic thresholds define the available notes that can be used for melody creation, e.g. from C3 to G6.
- **Size of Intervals**: In rules like No 9, there are several possible solutions for the notes selection. For example, small intervals would lead to a third, while big intervals would lead to a sixth.
- **Directions of Intervals**: Also, an interval may turn to either ascending or descending at its creation (provided the rule is allowed to follow both directions).
- **Rapidity of Melody**: This factor is affected by the colour saturation [3] and affects the notes values. Rapidity is ignored in this paper.

Possible options for parameterization of the synthesis algorithm are presented on Table 3.

5. EXPANSIONS: REAL IMAGES

An actual challenge, which this paper tries to accomplish in a novel way, is the implementation of the methods presented in section 4 for auditory display of real images. The actual procedure, which is followed here, consists of 3 steps:

1. Representation of the digitized image in terms of **pixels**.
2. Segmentation of the image in **segments** containing adjacent pixels with the same R-G-B colour values (each segment forms a chromatic brick).
3. Implementation of the 1st method (section 4.1) on the created bricks in order to extract the melody.

[1] By the term *transition of* χ, we mean the alteration of a colour to another, e.g. from yellow to red: transition from 1.3 to 1.5.

PARAMETER	OPTIONS

Ni Factors	• 1-5
	• 6-10
	• 11-15
	• in proportion to duration
	  o *1
	  o *2
	  o *3
	  o *4
	  o *5
	• Limits (From ? to ?)
	• Random

Size of Intervals	• Small (2nd –3rd) • Medium (4th – 5th) • Big (6th – 7th) • SMB (one small, followed by one medium and one big) • Random
Direction of Intervals	• Alternately • Purely Ascending or Purely Descending (until thresholds) • Alteration per two intervals • Alteration per brick • Random

Table 3: Configuration of variables for brick-driven synthesis in a parameterized environment.

The next section demonstrates these 3 steps on a small digital icon.

5.1. The *"Happy Face"* Composition 

We used a small colorful icon in order to show how an image can be converted to music. The 'pixelized' "Happy Face" icon can be seen in Fig. 7(a).

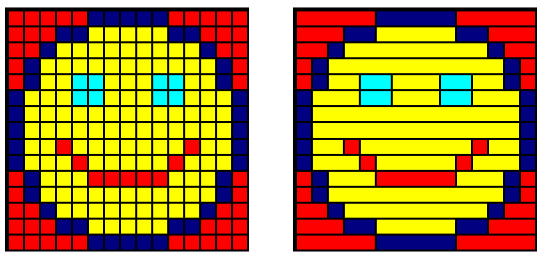


Figure 7. *(a) Colorful pixels of the "Happy Face" icon. (b)The bricks of the "Happy Face" Composition.*

The second step for the auditory display of this image is to define which are the bricks of this image (segmentation). The rule to use here is that the adjacent pixels of the same colour belong to the same segment. This process is implemented with the use of a *single point* [15]. The pointer scans the image beginning from the upper-left pixel and ending at the bottom-right pixel. The image is scanned line-by-line. The pointer indicates the continuous pixels with the same colour values and groups them to a single brick. The bricks of "Happy Face" can be clearly seen in Figure 7(b).

It is true that the procedure, which is described here, applies on the concatenated horizontal vector created from a figure. It should be noted here that the present work is only limited to the melodic line construction. The melody itself represents the horizontal vector on a music composition. According to Barsky, there are two types of chromaticism in music: the horizontal (melodic line) and the vertical (harmonics) [5]. No other dimensions are considered in this paper, since only the image-to-melody transition is concerned.

The final step is to apply the rules of section 4.1. to all the bricks in order to extract the melody. The chosen parameters for the conversion of "Happy FACE" are: **Ni Factors ≤ (number of meters)*4, Size of Intervals: SMB, Direction of Intervals: Alteration per two Intervals, Repetitions of Phrases: wherever possible**.

Each pixel is considered to represent a meter (tempo is chosen as 2/4). For simplicity, yellow bricks are considered to bear the chromatic value χ=1,2857 (instead of 1,3), while red bricks are considered to bear χ=1,4857 (instead of 1,5). This reduction allows the efficient use of the major and the Byzantine Plagal-D diatonic scales that bear 1,2857 and 1,4857 respectively as their *Scale Chroma by Nature* [3], [4].

The color percentage of the image leads to the correspondence to a scale from the database. "Happy Face" contains:

- 120 Yellow Pixels (χ=1,2857) → 53,3%
- 57 Red Pixels (χ=1,4857) → 25,3%
- 40 Dark Blue Pixels (χ=1,7) → 17,8%
- 8 Sky Blue Pixels (χ=1,2) → 3,6%

Considering the dominance of the yellow colour within the image, a scale with χ^0=1,2857 should be mapped to the piece. This is the major scale (G-major has been randomly chosen). Had we accepted the yellow colour value as 1,3, a new scale should have been defined, but this is not the point of the demonstration.

Some heuristic rules have been used here for great χ transitions:

- If the absolute value of the transition is greater than 1.3 and the second brick bears the dominant colour, then insert a rest at the end of the 1st brick and begin the 2nd brick in the selected piece's scale.
- If the transition is impossible to implement with the use of the ten rules, then insert a rest at the end of the 1st brick and begin the second brick in a scale with χ^0 close to its chromatic index (scale change).

Part of the extracted melody is shown in figure 8 in notation staff. The minimum interval of the composition is the quarter-tone, and therefore the half-flat (𝄳) and the half-sharp (𝄲) signs are used [3]. We can make some observations on the final auditory result. The first heuristic is used in all the cases when a yellow brick follows a dark blue brick. The second heuristic has been used in two cases: at meter no 29, where a red brick follows a dark blue brick and the Byzantine Plagal-D diatonic scale is applied, and also at meters 44 and 60, where a dark blue brick (with length equal to one meter) follows a yellow brick and G minor harmonic scale is applied (χ^0=1,857).

The concept of musical phrase repetitions in the piece is obvious in the extracted melody. The algorithm stores the first created phrase at the piece's scale (meters 21-25) and uses it in every possible way (once inside a brick). The repetitions of the phrase here occur in meters 37-41, 52-56 and 92-96. Also, a variation in another key occurs in meters 29-33.

Of course, we cannot describe in detail the whole conversion of the "Happy Face" pattern to music due to space constraints. Nevertheless, a demonstration of the first ten meters actual conversion follows:

Meters 1-5 represent the first red segment (χ=1,4857), while meters 6-10 represent the second dark blue segment (χ=1,7). The first step is to calculate the Ni factors for segment 1 (Ni ≤ 20). A random selection on the (6a) equation's results resulted in the following 5 Ni factors: 5,5,5,4,5 (Table 4).

Ni Factors		1+0,01*Ni	Notes Chroma	
N1	5	1,05	χ_1	1,350
N2	5	1,05	χ_2	1,417
N3	5	1,05	χ_3	1,488
N4	4	1,04	χ_4	1,548
N5	5	1,05	χ_5	1,625
		Segment's Average		**1,4858**

Table 4: Computing the chromatic elements of the first segment in the "Happy Face" pattern.

Factors 1,2,3 and 5 trigger the 4th rule of Table 2, while factor 4 triggers the 3rd rule. According to the 4th rule the melodic line moves in a purely chromatic way (in terms of semitones) for 3 meters. Since we configured the direction of intervals to *Alteration per two Intervals*, the first 2 factors (meters 1-2) are realized in an ascending pattern, while factor N3 (meter 3) turns to be descending. Also, the quartertone, which is the result of the 4th rule in meter 4, is descending. Again, a chromatic ascending movement in the 5th meter (constituting of 5 notes) is the result of N5. An important observation here is the equal distribution of factors in the 5 meters (one factor is implemented per meter).

The second segment represents a smooth transition from the last note of the first segment (χ_5 = 1,625) to 1,7. The transition requires only one factor: N1=4. Therefore, only a quartertone is enough to reflect this transition in meters 6-10. The effect takes place in meter 9. The movement at this point is descending.

The extracted melody of "Happy Face" has been implemented using C-sound. The sound file of "Happy Face" is [HAPPY_FACE.WAV].

As it has been mentioned, the method can be applied to digital images and photos. Because of the greatest amount of pixels in that case, smaller time units can be used, e.g. one pixel = ♪. A great advantage on the conversion of real images to melodies is that adjacent pixels bear such colors that smooth transitions usually occur. This is translated to well-turned compositions and better melodies. Figure 9 shows such smooth colour transitions. The figure consists a very small part of a digital image [MONUMENT.JPG].

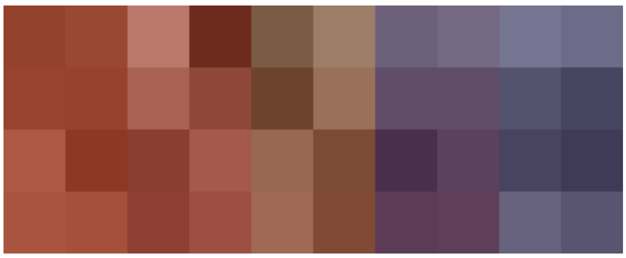


Figure 9. *Pixels of a small part of a digital photo. The χ transitions are smooth and therefore result to more sophisticated melodies.*

Figure 8. *Part of the extracted melody of the brick-driven "Happy Face" composition.*

6. FUTURE WORK

It should be obvious at this point that chromatic synthesis, as the reverse process of chromatic analysis [3], [4] is a complicated matter.

The next step of our research is to embed some (ignored at the moment) factors, which are crucial to the audience perception of chromaticism. Such factors include: brightness and saturation of colors [20], durations in ms (real-time synthesis), missing rules for notes extraction, rapidity of melodic sequences, musical ways of expression (e.g. staccato), etc.

The next stage of the research also includes taking into account the vertical vector of a figure in order to create the harmonics of a melody. This part is crucial, if we want to talk about full music compositions. Several melodic and harmonic lines (that are extracted from a digital image) could lead to a fully orchestrated musical piece.

As it has been mentioned before, the software tool for implementing the proposed methods is under development. We aim at the development of a human-centered functional interface for composing music by using colors in a fully parameterized environment.

Moreover, after the tool is finally developed, several experiments for testing the chromatic conversion accuracy are planned. The subjects of the experiments will be students of musicology, students of computer science, music composers and people who just like listening to music. The experiments are necessary in order to provide recall and precision measures that will lead to the improvement of the methods and the next steps of the research.

7. CONCLUSIONS

The methods that were described in this paper present some fundamental concepts of how to compose the melody of a musical piece by analyzing an image's colour values (chromatic synthesis). The two methods (self-creation of chromatic bricks and selection of bricks from a database) do not limit the freedom of the composer, since he / she can configure the whole process, in order to reach a certain degree of satisfaction on the auditory result.

The algorithm of the first method contains inherent fuzziness. Certain parameters need to be adjusted in order to improve the results. Several possible variable values to be adjusted are: the duration of the chromatic bricks, the amount of Ni factors, the melodic thresholds, the rapidity of melody, the size and the direction of the produced intervals.

The second method is more clearly defined and may be pertained as a very good solution to the question of chromatic synthesis, as a sonification method in music. Selecting bricks from a database to build the chromatic wall is just like putting puzzle pieces together. The final result is much more likely to be what the composer wanted to hear, especially if he has created all the bricks. Software solutions, like brick generators, or audio selectors (software that select specific segments of an audio or MIDI file and convert them to a brick format) make things much easier.

The colour attributes of digital images and figures can efficiently lead to a melodic representation. An integrated tool for chromatic synthesis is currently under development on the scope of the present research.

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