TRANSFORMATION OF COLOR IMAGES INTO MAIN AND BASS MELODY

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Abstract: The first part of this paper describes the algorithm for color image to musical note transformation (ItNT Algorithm). After that, a modified algorithm for color image to musical note transformation (MItNT Algorithm) was presented. The modification was made in the part of image spectrum analysis and selection of musical notes. The transformation was done in accordance with the emotional experience of red, green and blue. The authors, according to personal personal psychoacoustic criteria, chose music scales for the appropriate colors: Whole tone scale (red), b) Major scale (green) and c) Balcanic minor scale (blue). The second part of the paper describes an experiment in which the results of the transformation of ten world - famous art paintings into Main and Bass melodies using MItNT Algorithm are presented. Melodies are displayed using musical notes.

Key words: Image processing, Short Time Fourier Transform, Image to sound conversion, Zig-zag algorithm, Music scales.

1. INTRODUCTION

The effect of light and color on man has always been significant. The history of art points to the famous philosopher Pythagoras and his experience of light and color, who was emotionally inspired by observing the stars in the night sky on the island of Samos. Two hundred years later, Aristotle introduced the term Color Music. Aristotle believed that there is a physical connection between light and sound, that is, that every musical tone has a color [1]. The Jesuit philosopher and mathematician, Louis Bertrand Castel, studied Isaac Newton's Opticks, where the author, among other things, talks about the connection between some colors and sounds. Newton suggested that tone C, as the lowest note in the octave, be red, as the lowest frequency in the spectrum. For tone F, he suggested green. Inspired by the idea of connecting color and sound, that is, Color Music, Castel constructed a 'color organ'. By pressing a key on the keyboard, colored paper would appear above the organ. Castel decided that C should be blue because it ‘sounded blue’. For tone F, he suggested yellow.

Many attempts have been made to compose music from pictures, and vice versa (music-based painting). Also, tests were conducted with the aim of connecting colors and emotions. For example, red, yellow and blue are associated with the emotions of happiness, sadness, anger, respectively [2]. In [3]described an experiment where the connection between colors and emotions was created. The color red has been associated with *exciting* and *stimulating*, and both imply *pleasure* and high excitement. Blue was associated with comfortable and soothing. Orange was associated with anxiety, which implied dissatisfaction and high excitement. Black was associated with the powerful, which implied high dominance [4].

In [5] the connection of colors with the corresponding emotional state has been established: a) Red (Joi - the emotion of great delight or happiness caused by something exceptionally good or satisfying), b) Green (Acceptance, Optimism) and c) Blue (Fear, Sadness, Anticipation, Disappointment)

The algorithm for image to musical note transformation (ItNT Algorithm) is described in [6]. Emotion-based color transformation was used. First, the color image is decomposed into *Y* and *RGB* layers. The idea is to form two independent melodies from the picture (Main melody and Bass melody). The main melody is created based on the luminant *Y* layer of the image, because the luminant layer contains more information about the details in the image. To create a Bass melody, one of the *RGB* layers, which has the highest pixel intensity, was selected. The layer thus selected is called the

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dominant layer. For each layer, the authors predicted appropriate musical scales based on the emotional experiences of red, green and blue. Based on their personal psychoacoustic criteria, the authors chose: a) Hijaz scale (red), b) Major scale (green) and c) Pentatonic scale (blue). The authors connected the color red with Eastern music through the Hidjaz scale.

In this paper, the authors performed a modification of the ItNT algorithm (MItNT algorithm) shown in [6]. The modification of the ItS algorithm was performed in the part of signal spectrum analysis and music note selection. Taking the appropriate musical experience and personal psychoacoustic criteria, the authors of this paper decided on the following musical scales: a) Whole tone scale (red), b) Major scale (green) and c) Balcanic minor scale (blue). The scales are associated to color red, green and blue respectively. A Whole tone scale consists of whole degrees, without any half tone. Due to the non-existence of the semi-degree, it causes constant tension in its melody, which is associated with the color red. The Balcanic minor scale was chosen in accordance with the emotional music of the Balkans. The second part of the paper describes an experiment in which the MItS algorithm was applied to images from the database in order to create musical notes. The database of image is formed of the ten most famous images: a) Mona Lisa (Leonardo da Vinci), b) The Last Supper (Leonardo da Vinci), c) Creation of Adam (Michelangelo), e) The Starry Night (Vincent van Gogh), e) The Scream (Edvard Munch), f) The Persistence of Memory (Salvador Dali), d) Girl With a Pearl Earring (Johannes Vermeer), h) The Night Watch (Rembrandt), i) Self-portrait without beard (Vincent van Gogh) and j) Guernica (Pablo Picasso). [https://www.10naj.com/10-najpoznatijih-umetnickih-slika-na-svetu/].

Further organization of this paper is as follows. Section 2.1 shows the ItNT algorithm. Section 2.2 shows the MItNT algorithm. Section 3 shows the image transformation algorithm. Section 4 is the Conclusion.

2. IMAGE TO NOTE TRANSFORMATION ALGORITHMS

2.1. ItNT Algorithm

In [6], an algorithm for the transformation of images into music, that is, into a music record using notes, is described. The Image to Note Transformation, ItNT, algorithm was implemented in the following steps:

Input: Image X, dimension M x N

Output: Music notes

Step 1: Decomposition image I into *RGB* layers.

Step 2: Determining the sum of the pixels intensity in layers R (S_R), G (S_G) and B (S_B).

Step 3: Determining the dominant I_{dom} layer based on $S_{\max} = \max(S_R, S_G, S_B) \Rightarrow I_{dom}$

Step 4: Selecting the type of the musical scale based on the dominant I_{dom} and psychoacoustic criteria.

Step 5: Dividing the dominant I_{dom} layer into blocks.

Step 6: Using FFT the spectrum for each block, X_{dom}, of the dominant layer is calculated .

Step 7: The maximum spectral component is pecked using a ring filter.

Step 8: According to the position of the maximum spectral component, the note for the Bass melody in F clef is defined.

Step 9: Creating an I_{prim} layer (luminentnt component of image).

Step 10: Dividing the I_{prim} layer into blocks.

Step 11: Using FFT for each block of the I_{prim} layer the spectrum X_{prim} is calculated.

Step 12: The maximum spectral component is pecked using a ring filter.

Step 13: According to the position of the maximum component, the note for Main melody in G clef is defined.

Each *RGB* layer, in accordance with psychoacoustic criteria, evokes an emotional experience in a person. The color red indicates wilderness and passion. Green is known as a color that indicates joy and good mood. The blue color indicates comfort and relaxation. According to personal psychoacoustic criteria, the authors proposed the following correlation [6]. The red color (*R* layer) is joined by the Hidjaz music scale. The green color (*G* layer) is joined by the Major scale. The blue color (*B* layer) is joined by the Pentatonic scale.

2.2. MItNT Algorithm

The authors of this paper created the Modified Image to Note Transformation (MItNT) algorithm by modifying the ItNT algorithm [6]. The modification was performed in the part of establishing the correspondence between the energy distribution in the spectrum of the Dominant RGB layer and the Primary layer and selecting the appropriate note. Instead of filtering the image spectrum using a ring filter, the following was done: a) converting a two-dimensional spectrum of image into a one-dimensional spectrum using the Zig-zag algorithm (*Step 7*, *Step 12*) and b) picking the maximum spectral component and selecting the appropriate note in the selected music scale (*Step 8*, *Step 13*). Modified steps in the MItNT algorithm are:

Step 7: Creating a one-dimensional spectrum using the Zig-zag algorithm: Y_{dom} = ZigZag(X_{dom}).

Step 8: Divide the spectrum Y_{dom} into subbands, depending on the number of notes in the corresponding music scale. Selecting the subband with the largest spectral component (Ym_{dom}). Selection of a music note from the scale for the Bass melody in F clef according to selected subband ($Ym_{dom} \rightarrow$ ♪).

Step 12: Creating a one-dimensional spectrum pomocu Zig-zag algoritmom Y_{prim} = ZigZag(X_{prim}).

Step 13: Divide the spectrum Y_{prim} into subbands, depending on the number of notes in the corresponding music scale. Selecting the subband with the largest spectral component (Ym_{prim}). Selection of a music note from the scale for the Main melody in F clef according to selected subband ($Ym_{prim} \rightarrow$ ♪).

According to the personal emotional experience of colors and music scales, the authors of this paper suggest the following connection between RGB layers and music scales: a) *R* layer - Whole tone scale, b) *G* layer - Major scale and b) *B* layer - Balcanic minor scale (Figure 1).

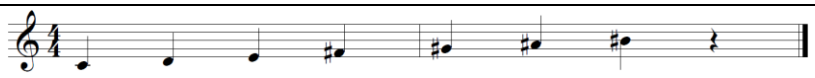
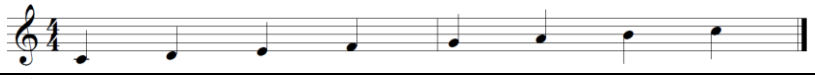
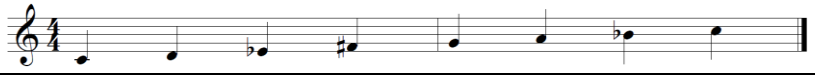
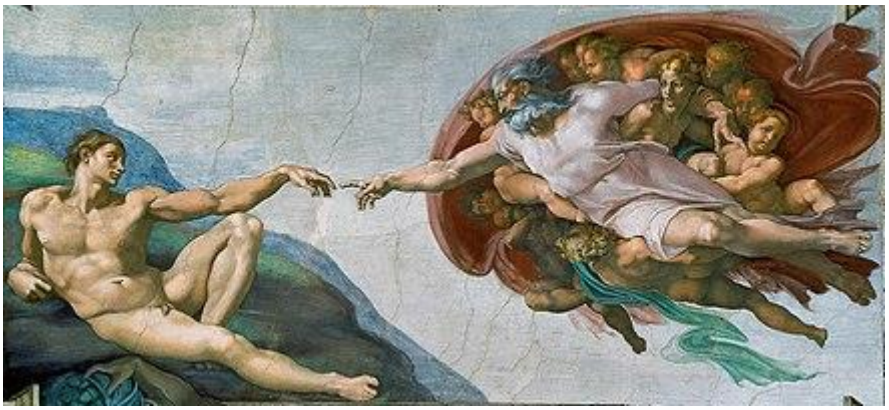
Layers	Music scales	
R	Whole tone scale	
G	Major scale	
B	Balcanic minor scale	

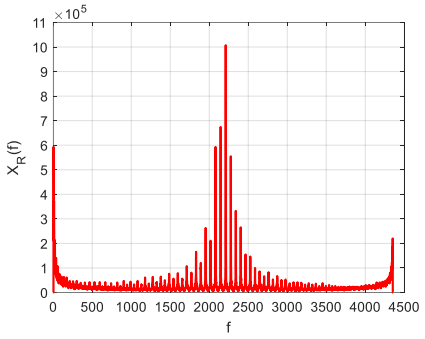
Image 1 – The music scales used for the Image to Note transformation

Example of MItST algorithm application: Transformation of the image of Creation of Adam (Fig. 2.a) into musical notes. Decompose the image into *RGB* layers (Step 1): *R* (Fig. 2.b), *G* (Fig. 2.d) and *B* (Fig. 2.f). Calculate spectrum of the *RGB* layers (Step 6): *R* (Fig. 2.c), *G* (Fig. 2.e) and *B* (Fig. 2.d). Creating a Primary Layer I_{prim} (Step 9). Calculation of the spectrum of the I_{prim} layer (Fig. 2.i). The color R is dominant and the Whole tone scale is selected (Fig. 2.j).

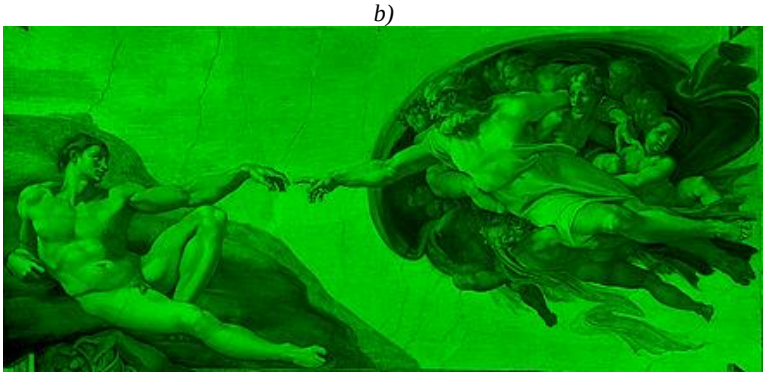


a)

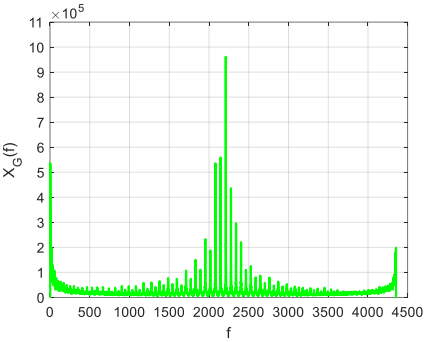
b)



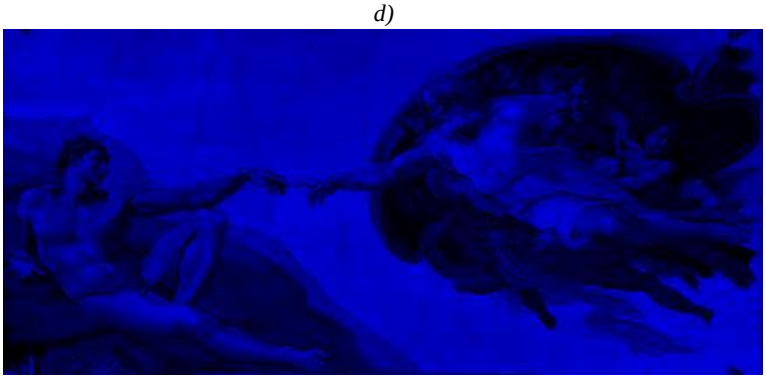
c)



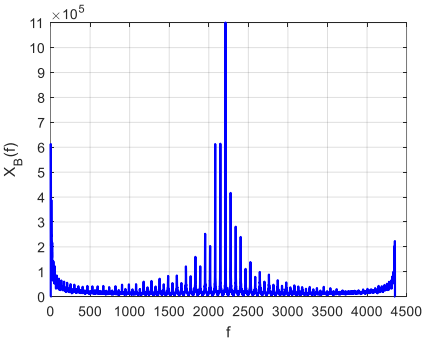
d)



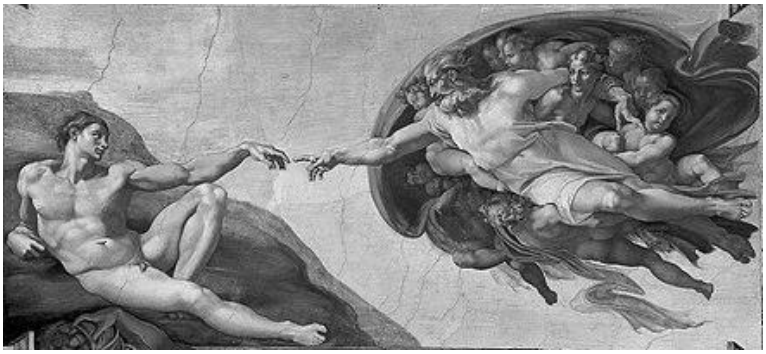
e)



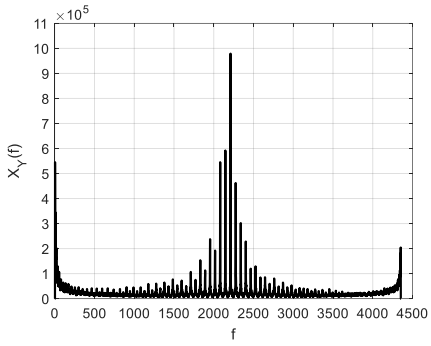
f)



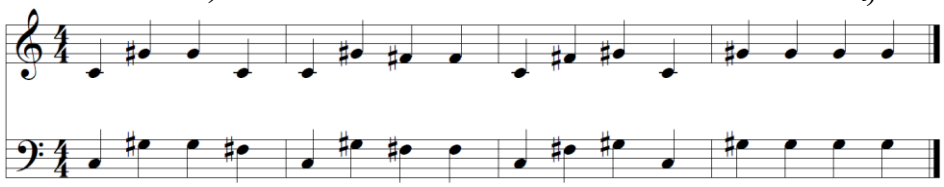
g)



h)



i)



j)

Image 2 – a) Image Creation of Adam, b) R layer, c) spectrum of the R layer, d) G layer, e) spectrum of the G layer f) B layer, g) spectrum of the B layer h) Primary layer i) spectrum of the Primary layer, and j) Whole tone scale.

3. EXPERIMENT AND RESULTS

3.1. Experiment

The experiment, in which the Test image from the Test Database was processed using the MItST algorithm, was performed. As a result of applying the MItST algorithm on each Test image musical notes were generated. The results of processing each Test image, selected music scale and note of Main and Bass melody are presented in Table 1.

3.2. Test image base

The Test Image Database is created from 10 of the world's most important paintings (Fig. 3): a) *Mona Lisa* (Artist: Leonardo da Vinci, Estimated date: 1503 to 1519), b) *The Last Supper* (Artist: Leonardo da Vinci, Estimated date: 1495 to 1498), c) *Creation of Adam* (Artist: Michelangelo, Date: 1508 to 1512), d) *The Starry Night* (Artist: Vincent van Gogh, Date: 1889), e) *The Scream* (Artist: Edvard Munch, Date: 1893), f) *The Persistence of Memory* (Artist: Salvador Dali, Date: 1931), g) *Girl With a Pearl Earring* (Artist: Johannes Vermeer, Date: 1665), h) *The Night Watch* (Artist: Rembrandt, Date: 1642), i) *Self-portrait without beard* (Artist: Vincent van Gogh, Date: 1889) and j) *Guernica* (Artist: Pablo Picasso, Date: 1937).

a)

b)

c)

g)

d)

e)

h)

i)

f)

j)

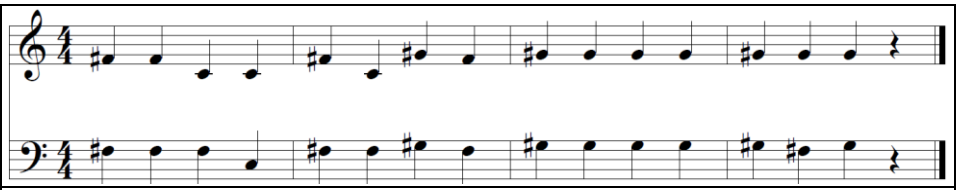
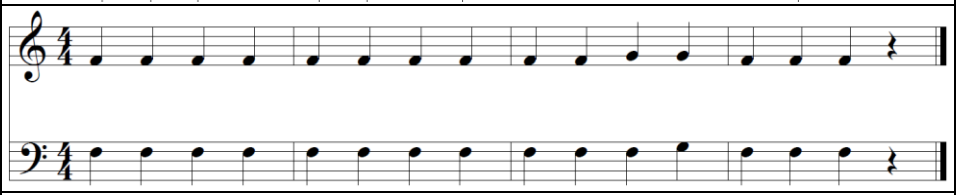
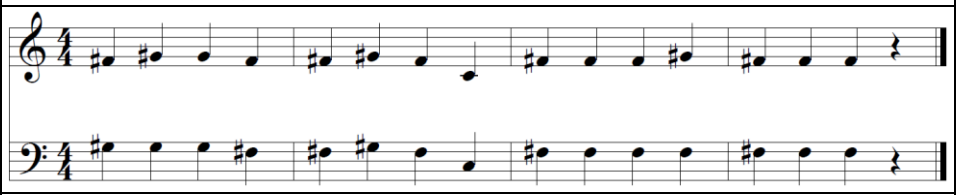
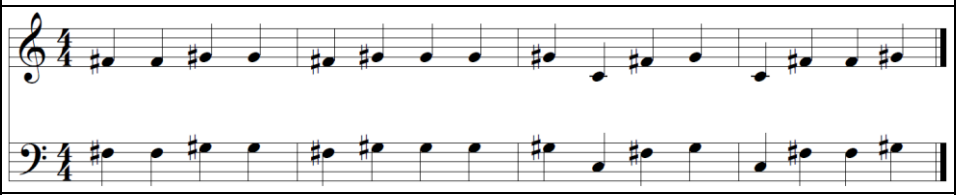
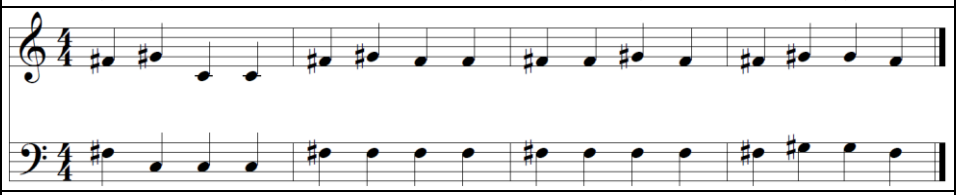
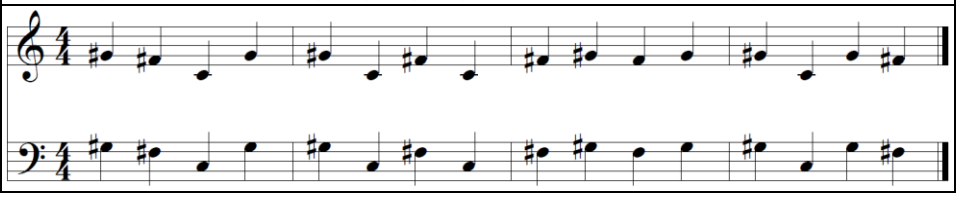
Image 3 – Test image: a) Mona Lisa, b) The Last Supper, c) Creation of Adam, d) The Starry Night, e) The Scream, f) The Persistence of Memory, g) Girl With a Pearl Earring, h) The Night Watch, i) Self-portrait without beard and j) Guernica.

3.3. Results

The results of processing each Test image, selected music scale and note of Main and Bass melody are presented in Table 1.

Table 1 – Test image, assigned music scales and Main and Bass melodies.

	Image	Scale	Note of Main and Bass Melodies
1.	Mona Lisa	Whole tone scale	
2.	The Last Supper	Whole tone scale	
3.	Creation of Adam	Whole tone scale	
4.	The Starry Night	Balcanic minor scale	

5.	The Scream	Whole tone scale	
6.	The Persistence of Memory	Major scale	
7.	Girl With a Pearl Earring	Whole tone scale	
8.	The Night Watch	Whole tone scale	
9.	Self-portrait without beard	Whole tone scale	
10.	Guernica	Whole tone scale	

3.4. Analysis of results

Based on the results shown in Table 1 (selected music scale and note of Main and Bass melody), it can be seen that the dominant layer is *R* in 8 images. Layer *G* is dominant at one image (The Persistence of Memory, Major scale). Layer *B* is dominant at one image (The Starry Night, Balcanic minor scale).

4. CONCLUSIONS

The paper presents the MItST algorithm for the transformation of color images into sound, ie musical notes, and, in this way, the Main and Bass melody is generated. Based on the dominant participation of individual colors in the image (*RGB* layers), the application of psychoacoustic criteria to classify into one of the emotional categories is used: a) passion (dominant layer *R*), b) joy, good mood (dominant layer *G*), and c) comfort and relaxation (dominant layer *B*). According to the personal criteria, the authors proposed music scales: a) Whole tone scale (dominant layer *R*), b) Major scale (dominant layer *G*), and b) Balcanic minor scale (dominant layer *B*). A Test Image database has been formed, consisting of the ten most famous images. Using the MItST algorithm, the images were transformed into musical notes, that is, into Main and Bass melodies. The results show that the Whole tone scale was selected for eight images, while Major and Balcanic minor scale were associated with one image each.

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