

A Musical Classification and Interpretation of Abstract Art

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ABSTRACT

While different forms of art have been integrated in few fields such as architecture, graphic design or even engineering (video game design for instance), they have most of the time been represented separately as monastic elements. Motivated to find an automated link between two forms of art: music and abstract art as well as to provide a unique experience for visually challenged people in presence of abstract art, we propose in this work ArtMus, a novel approach to listening to an abstract art. ArtMus after scanning in real time the abstract art would classify it and output a melodic tune based on the combinations of colors available in the abstract art as well as the pattern the user is using to traverse the abstract art. Limited experimental results show the merit of the proposed approach in providing some affective computing for abstract art and motivate follow on research.

General Terms

Algorithms, Experimentation, Human Factors.

Keywords

Music Interpretation, Classification, Color and Emotions, Affective Computing.

1. INTRODUCTION

One in every 200 individuals is diagnosed with some form of synesthesia [1]. One common type of synesthesia is color-auditory in which the perception of colors, textures, and shapes produce sounds in the person's head [1]. So for synesthesia disease free persons, imagine what it would be like to listen to the Mona Lisa, or even listen to the painting in your living room. Well, this is what our project aims to develop. More precisely, we try to find some affective link between two forms of art: music and abstract art. Providing such a connection would not only open up novel interaction with art and affective computing but most importantly it will enhance the visually challenged people's experience in art. Many researchers have attempted to find a correlation between the five human senses and more particularly to establish a certain standard relationship between visuals and audio. [2] discusses the most eminent works of Frederick Kastner's Pyrophone, the Bainbridge Bishop's device for "painting music", the Rimington "color organ" and Castel's and later "clavecin oculaire" Jameson, Schooling and Wilfred contributions who all attempted to translate sound into color since the 18th century. Other visual-audio mappings were proposed through the "Harmonic Coloring" which refers to the act of directly mapping the 12 colors found in the color wheel to the 12 pitches from the circle of fifth [3], the Pythagorean theory of music and colors of mapping colors to notes based on the law of the octave [4], and through one color to one note association such that the works of [5-10].

Differently from literature, our approach, ArtMus analyzes the piece of abstract art based on the Kobayashi scale [11] that relates 3-color combinations to an emotion. Based on the color combinations, ArtMus will associate a certain overall "mood" to

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the abstract art, which will in turn select background chords conveying that mood. Since in music theory, each mode matches a certain emotion, the background chords will depend on the mode corresponding to the mood of the image. Once a mood is defined, the background chords will start playing in a pseudo-random way

based on a chord-map that corresponds to the selected mode. In addition, a selection of notes that relate also to the same mood will be assigned to the different colors in the painting. As the user moves his/her finger across the abstract art, a unique combination of chords will be played based on the pattern followed to traverse the abstract art. It is as if, the user becomes the soloist over the chords, generating notes and melodies in real time while moving over the painting. The collaboration of the musical notes played by the user and the background music would convey the same global emotion however with a unique user's experience.

The remaining of this paper is structured such that Section 2 details ArtMus, while Section 3 presents experimental results. Section 4 concludes the paper with follow on research directives.

2. ArtMus

While no similar project has been found in literature, ArtMus relies on a combination of established colors theories and music moods merged in a novel way.

2.1 Combination of Colors to Emotion Theory

Since color combination is essential to determine the emotion of an object, [8] has developed a scale of 130 colors with a variety of different three-color combinations and associated them with an emotion or a mood. Kobayashi classifies a color according to its hue, its tone and accordingly its position in the grid he introduced in his book entitled "Color image Scale" [8]. A color combination image scale and a keyword image scale are presented in the following figure 1. The vertical axe shows the variation of the tone from hard to soft, whereas the horizontal axis is a measure of the hue that varies from warm to cool. On this grid, color combinations that resemble each other are grouped together into categories so that each color combination's distinguishing characteristics are easier to see.

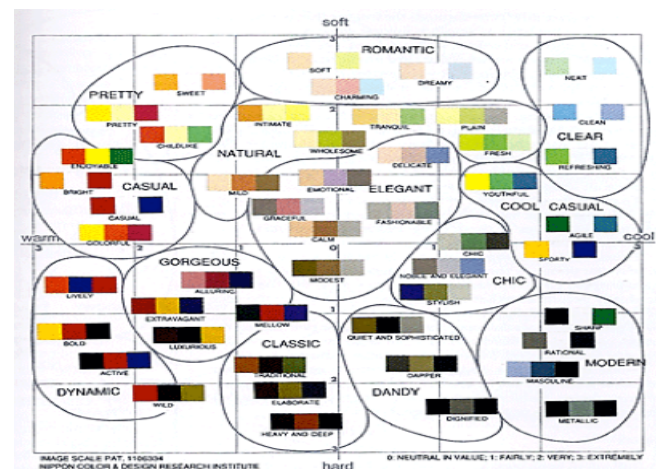


Figure 1. Color Combination Image Scale [11]

2.2 Chord and Scale Theory

Originally created by the ancient Greeks, the seven modes of music as they are referred to by modern music theory are: Ionian (C), Dorian (D), Phrygian (E), Lydian (F), Mixolydian (G), Aeolian (A) and Locrian (B). Each of these modes can relay a certain emotion to the listener. The major modes, which are the Ionian, Lydian and Mixolydian give a feel of happiness, gracefulness and solemnity; whereas the minor modes such as the Dorian and the Aeolian convey sadness, dreaminess, disgust or anger [12]. For every mode there is a matching chord and a set of specific notes. [13] classified the scale mappings for each chord type as shown in table 1.

Table 1. Chord to Scale Mapping

Chord	Scale	Notes
Cmaj7	Major (avoid 4th)	C D E G A B
C7	Mixolydian (~ 4th)	C D E G A Bb
Cm7	Minor (avoid 6th)	C D Eb F G Bb
Cm7b5	Locrian (~2nd)	C Eb F Gb Ab Bb
Cdim	W/H Diminished	C D Eb F F# G# A B
C+	Lydian Augmented	C D E F# G# A B
C7+	Whole Tone	C D E F# G# A#
C7#11	Lydian Dominant	C D E F# G A Bb
C7#9	Altered Scale	C Db Eb E F# G# Bb
C7b9	H/W Diminished	C Db Eb E F# G A Bb
Cm7b9	Phrygian	C Db Eb F G A Bb
Cmaj7#11	Lydian	C D E F# G A B

The Major scale refers to the Ionian mode (“happiest mood”), and the Minor scale corresponds to the Aeolian mode (“saddest mood”). As shown in table 1, the “happiest mood” corresponds to a melody formed by a combination of the C, D, E, G, A and B notes having mainly the Cmaj7 chord in the background [14]. Therefore, the first 3 rows will be associated with the very happy, happy and sad moods respectively. However, the very sad mood will be defined by the Dorian scale, the C, D, Eb, F, G, A and Bb notes and mainly the Eb chord. The background chords corresponding to each mood will follow the map relative to the dominant chord. For instance, when the Cmaj7 chord is dominant, the starting chord is C. Only from C, the transition to any other chord on the chart is possible. But once a particular chord is played, there are specific rules that should be followed as illustrated figure 2 and table 2.

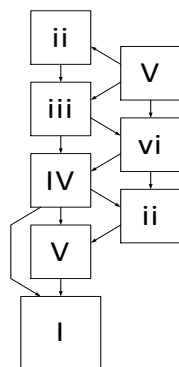


Figure 2. Simple Music Transition Flow [15]

Table 2- Chord Table [15]

KEY	I	ii	iii	IV	V	Vi
C	C	Dm	Em	F	G	Am
Db	Db	Ebm	Fm	Gb	Ab	Bbm
D	D	Em	F#m	G	A	Bm
Eb	Eb	Fm	Gm	Ab	Bb	Cm
E	E	F#m	G#m	A	B	C#m
F	F	Gm	Am	Bb	C	Dm
Gb	Gb	Abm	Bbm	Cb	Db	Ebm
G	G	Am	Bm	C	D	Em
Ab	Ab	Bbm	Cm	Db	Eb	Fm
A	A	Bm	C#m	D	E	F#m
Bb	Bb	Cm	Dm	Eb	F	Gm
B	B	C#m	D#m	E	F#	G#m

2.3 ArtMus Design

ArtMus overall workflow is depicted in figure 3. A scan of the overall abstract art is required so that to identify the global mood from the color combinations. Once the mood is determined, corresponding chords are selected for the background music with a tempo determined by the art’s mood. Finally, a unique sequence of notes will be played based on the pattern the abstract art is traversed/ “played”.

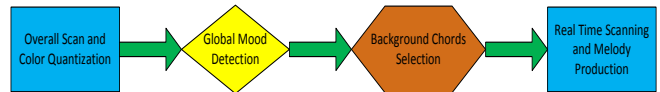


Figure 3. ArtMus Workflow

2.3.1 Mood Detection

The Kobayashi grid previously illustrated in figure 1 is divided into 4 quadrants to which we assigned the 4 moods we are basing our analysis on: Warm-Soft (“very happy”), Cool-Soft (“happy/calm”), Cool-Hard (“very sad/gloomy”), Warm-Hard (“sad/dangerous”). Once an image is processed, we detect the RGB values of each pixel in the image. Then, a histogram displaying the occurrences of each color is generated. In addition, the colors are grouped according to their tone: Vivid, Bright, Pale, Light, Grayish/Dull and Dark, as shown in table 3. The Neutral category is added to these tones since it has unique characteristics.

Table 3- Hue-Tone RGB Conversion Table

	R	YR	Y	GY	G	BG	B	PB	P	RP	Neutral
Vivid	207<R<255	207<R<255	207<R<255	106<R<206	0<R<105	41<R<105	0<R<60	0<R<40	41<R<160	200<R<255	231<R<255
	0<B<40	106<G<150	207<G<255	106<G<206	207<G<255	100<G<255	0<G<255	60<G<119	0<G<105	0<G<105	231<G<255
Bright	207<R<255	207<R<255	207<R<255	106<R<206	60<R<105	20<R<59	0<R<39	40<R<105	190<R<206	200<R<255	191<G<230
	41<G<119	120<G<206	207<G<255	120<G<206	120<G<206	120<G<206	120<G<206	120<G<206	190<G<206	0<G<105	191<G<230
Pale	207<R<255	207<R<255	340<R<255	200<R<225	150<R<219	130<R<219	120<R<160	140<R<200	201<R<220	221<R<255	141<R<190
	100<G<169	170<G<219	231<G<255	220<G<255	200<G<255	200<G<255	180<G<255	0<G<190	180<G<210	170<G<210	141<G<190
Light	190<R<206	190<R<206	230<R<255	190<R<206	141<R<179	150<R<219	100<R<119	201<R<220	180<R<206	180<R<206	106<R<140
	100<G<140	141<G<169	190<G<206	141<G<169	141<G<179	150<G<206	100<G<160	100<G<179	0<G<60	141<G<189	106<G<140
Grayish/ Dull Tone	0<B<40	0<B<40	41<B<105	41<B<105	51<B<100	141<B<220	150<B<206	180<B<255	100<B<209	100<B<160	106<B<140
	190<R<206	190<R<206	341<R<179	100<R<140	100<R<140	100<R<140	41<R<60	100<R<140	41<R<60	100<R<160	51<R<105
Dark	0<G<60	61<G<105	106<G<179	90<G<179	50<G<179	50<G<179	0<G<49	50<G<179	41<G<60	0<G<60	0<G<50
	0<B<40	41<B<60	0<B<60	0<B<60	0<B<60	0<B<60	0<B<60	61<B<105	41<B<105	41<B<60	0<B<50

This table has been constructed by combining data from Kobayashi’s Hue and Tone system [8] and the 216 safe color chart available online through several iterations by trial and error. To be able to relate to Kobayashi’s classification system, we identified the placement of those categories in the Kobayashi grid on a similar grid as shown in figure 4.

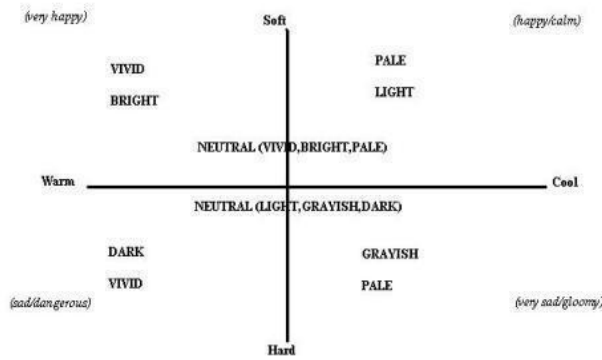


Figure 4- ArtMus Relationship Between Tones and Quadrants

Since every quadrant is associated with 3 color categories (with the neutral categories divided evenly between the upper and lower parts), the occurrences of all categories are taken into consideration and placed in their respective quadrants (Some categories like “Pale” will be accounted for in more than 1 quadrant). The quadrant receiving the highest number of occurrences will be the mood determinant for the abstract art.

2.3.2 Background Chords Generation

The background chords corresponding to each mood follow the map relative to the dominant chord. For instance, when the Cmaj7 chord is dominant (very happy mood), the starting chord is C. Only from C, the transition to any other chord on the chart is possible. But once a particular chord is played, there are specific paths that should be followed as illustrated by the simple map in figure 2. The generated chords relate to one mood and keep the feel of the global emotion by playing the key chord after every 4 measures.

2.3.3 Note Distribution

To insure user control and reproducibility of melodies, different octaves of the same note are assigned to the different shades of that particular color. For example, when in a very sad mood, the note C is assigned to Red: a vivid/bright red will be played by a C5, a pale/light red played by C4 and a greyish/dark red by a C3. It is important to note however, that since each mood possesses a different set of 7 notes assigned to it, we regrouped the hues into 7 blocks and the tones into 3 categories. The 3 categories will be assigned to 3 octaves. Table 4 displays the distribution of notes on colors depending on the mood detected. The adopted design not only allows a systematic mapping of notes to colors but also makes our application behave as an instrument where the user has control over the melodies he/she is generating and has the possibility to reproduce a certain sequence of notes when desired.

2.3.4 Implementation

The implementation workflow of ArtMus is shown in figure 5. ArtMus scans the painting and detects the number of occurrences of each color and instantaneously generates a flagged figure: each color is matched to a certain note and the flag number corresponds to the octave at which that note is played. In the meantime, the number of occurrences is stored and can be shown in a histogram.

Table 4- Distributions of Notes on Colors

DANGEROUS							
COLORS							
	R	YR	Y	GY-G	BG-B	PB	P-RP
NOTES	C	D	E ⁵	F	G	A	B ⁵
Vivid/Bright	C4	D4	E ⁴	F4	G4	A4	B ⁴
Pale/Light	C3	D3	E ³	F3	G3	A3	B ³
Grayish/Dark	C2	D2	E ²	F2	G2	A2	B ²

VERY SAD							
COLORS							
	R	YR	Y	GY-G	BG-B	PB	P-RP
NOTES	C	D	E ⁵	F	G	A	B ⁵
Vivid/Bright	C5	D5	E ⁵	F5	G5	A5	B ⁵
Pale/Light	C4	D4	E ⁴	F4	G4	A4	B ⁴
Grayish/Dark	C3	D3	E ³	F3	G3	A3	B ³

VERY HAPPY							
COLORS							
	R	YR	Y	GY-G	BG-B	PB	P-RP
NOTES	C	D	E	F	G	A	B
Vivid/Bright	C6	D6	E6	F6	G6	A6	B6
Pale/Light	C5	D5	E5	F5	G5	A5	B5
Grayish/Dark	C4	D4	E4	F4	G4	A4	B4

HAPPY CALM							
COLORS							
	R	YR	Y	GY-G	BG-B	PB	P-RP
NOTES	C	D	E	F	G	A	B ⁵
Vivid/Bright	C6	D6	E6	F6	G6	A6	B ⁶
Pale/Light	C5	D5	E5	F5	G5	A5	B ⁵
Grayish/Dark	C4	D4	E4	F4	G4	A4	B ⁴

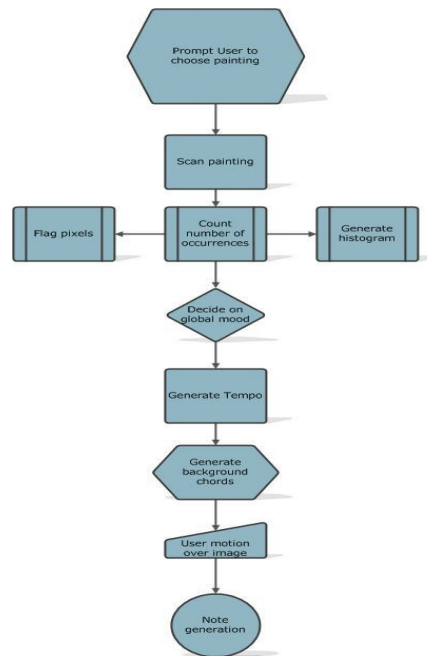


Figure 5- ArtMus Implementation Flowchart

The mood with the highest value becomes the mood of the painting. However, to account for the error that might be made while choosing this mood, the duration of each of the background chords is determined by a weighted sum of the 4 moods. Therefore, once the global mood is set, a switch case selects the corresponding chords and starts generating a pseudo-random series of chords. It is pseudo-random because every 4 measures, the key chord must be played then followed by the rest of the chords following the map. After the background chords are generated, the figure appears on the screen and the user has the ability to hover over it, click or drag the mouse. The current position of the pointer is used to call a note file. The notes are played on top of the background chords to create the melody.

3. Experimental Results

We ran several tests on images to insure that every pixel has a color assigned to it. We created flags for the colors and displayed flagged images to make sure that everything was covered. This actually helped in visualizing how the notes will be partitioned over the painting. In total, we used 22 flags (7 notes corresponding to 7 colors * 3 octaves + 1 for neutral colors) in our tests. Figure 6 show the histogram while figures 7 and 8 represent the original and flagged images of 2 of the 20 test images we tried.

Even though the mood was detected based on color theories, we wanted to double-check it with human color and music perceptions. Therefore, we polled the opinion of few users and asked them to classify pieces of abstract art based on colors alone according to four options: Very happy, Happy, Dangerous and Very Sad. After comparing ArtMus's result with the users' opinion, it turned out that ArtMus was satisfactory ie, when using strictly abstract paintings where shapes weren't a major component and colors were the only judging criterion. To make sure that the background chords generated by ArtMus were acceptable, we exported the outputted midi files of each run and played it in a midi editor. This editor allows us to view the notes, their duration, the beat as well as many other parameters. To verify that the required factors were correctly set, we compared the results obtained in the midi editor with our calculated parameters when the users were "playing" the abstract art.

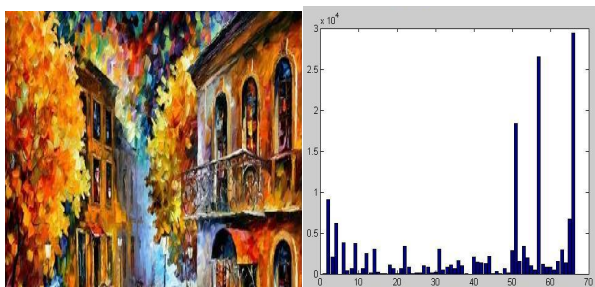


Figure 6- Illustration of Color Occurrence Histogram

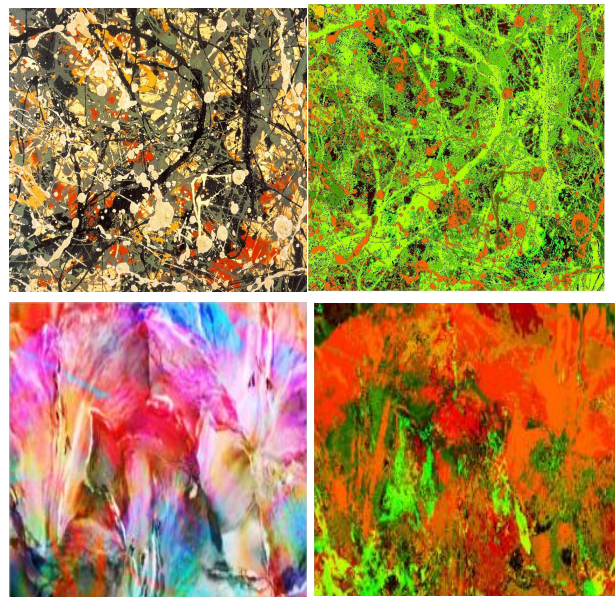


Figure 7- Illustrations of Original and Flagged Art

4. Conclusion

We have demonstrated in this work a musical approach to identify and interpret abstract art in an affective computing manner. ArtMus relied on combination of colors theory as proposed by [11] to interpret an abstract art. While limited experimental results show the merit of this approach, future work plans on incorporating the impact of shapes and patterns in the musical interpretation of art because shapes and patterns in an image are essential to the understanding of emotions in art.

ACKNOWLEDGMENTS

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