Subjective tests for gathering knowledge for applying color grading to video clips automatically

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The analysis of film music concerning caused emotions may allow for a more accurate adaptation of the color of the film in the context of color grading. Therefore, this paper aims to gather knowledge on the correlation between the applied color palette to a video clip, music associated with a particular shot, and emotions evoked. For that purpose, subjective tests are prepared in which several video clips are presented with or without the accompanying music along with several models to describe emotions. The test is composed of three stages. First, video shots are presented: the role of the viewer is to assign the associated emotion on graphs representing the emotion model (Hevner's, Thayer's, Plutchik's). The first part of the test is organized to check which of the emotion models is the easiest to associate the adapted color grading with emotion. Then, the test is repeated with the chosen psychological model on new video shots. The final phase consists of testing the same video shots but with accompanying music. In the paper, the meaning of the color in the film is explained based on the psychology of the color in film production. To analyze the sound path of the film, both low- and high-level parameters are given. Also, objective color measures corresponding to the tested film video shot are recalled. Assumptions for detecting emotions in the video shots to apply color grading automatically are also depicted.

Keywords-component; color grading, film production, mood models, emotions detection, film music

I. Introduction

This paper is an attempt to analyze the correlation between the color, music, and emotions evoked by a movie scene presented. Kubrick, film director, said: "Music is one of the most effective ways of preparing an audience and reinforcing points that you wish to impose on it." This may contradict our knowledge of human perception, which is conditioned by visual information to the most considerable extent. When analyzing the correlation between these three elements, it should also be taken into account that pre-defined movie director intentions and initial thoughts on the movie content and storytelling determine film genre and underly (post-)production aesthetic [1]. Thus, several subjective tests are carried out to retrieve information on how people perceive a given scene when its accompanying soundtrack is present or not and what emotions they assign in terms of color reception. The aim of the experiments is to decide also what model of emotions/moods (Hevner's, Thayer's, or Plutchik's) fits best the selected scenes.

The color in the film is usually assigned to a specific movie genre but also depends on its creators. Some solutions and standards are often used by the greatest directors in their movie productions to emphasize the stories and emotions associated with the characters through whose emotions audiences are connecting with them. Plausibility of a character is one of them. The coloring of the films, based on the psychology of colors, is certainly another one. For example, yellow can be associated with treason, but that does not mean that the whole scene is colored in yellow if this is the central theme behind it.

Another important part of movie production contributing to the reception of the film by the viewer is film music, which, created for the needs of a given film by the composer, also influences the perception of the story throughout the spectacle, influencing audience' emotions. As such, music is an inseparable part of causing the viewer's emotions; it is mainly that the movie releases emotions and empathy towards the characters.

II. Color Theory

A. Features of a color and color correction of a film

The main four color features are as follows:

- Hue – also named a tone, it refers to the wavelength of light. This feature allows specifying the names of the primary colors such as: red, green, blue. In the film industry, the shade is defined as a phase.

- Chroma – refers to the intensity of the color.

- Value – this parameter is responsible for the level of light and shadow.

- Color temperature – this parameter defines cold and warm colors: i.e., from 5000 K (which defines cold colors) and 2700-3000 K (which defines warm colors). This parameter is measured in Kelvin degrees.

The RGB (red, green, and blue) model is defined as the basic colors palette in the video industry. It is an additive color model that is created by mixing signals. Colors such as magenta, cyan, and yellow are derivative colors, created by combining two

primary colors from the RGB model [2]: magenta – a combination of red and blue; cyan – a combination of blue and green; yellow – a combination of red and green.

Two essential terms can be distinguished associated with the work on the color of a film: color correction and color grading [3].

- Color correction – is a unification of shots to maintain the consistency of a story. During shot realization for long scenes, many main elements create small incoherent scenes; these elements can be: different sources of light, changing the weather, various interiors, or diversity of places. Working on color correction, a filmmaker should change the level of white balance, level of black, saturation, unify the contrast, or change the overall color temperature.

- Color grading – it is the creative process of a filmmaker. The task of color grading is to saturate the image with the appropriate color characteristics and fill-up a story. It is the next step where colorist creates the actual aesthetic of the video. The right color grading does help convey a visual tone or mood to heighten the narrative. For example, colorists use darker tones to elevate the storytelling in a horror film.

III. MEANING OF THE COLOR IN FILM PRODUCTION

The most important task of the color grading and color scheme in the film production is to create an appropriate climate of a scene, emotional and visual separation of the scenes. For example, a cheerful holiday idyll, where the heroes are shown at the seaside, who rest in a sunny day can be presented in warm colors to create a happy atmosphere, while the scene of drama taking place due to climate change and atmospheric phenomena are created in cold blue colors. However, in war dramas, a palette of colors will be desaturated, but in comedy, a wide palleted of color will be used, which is associated with joyful moments [4], [5], [6].

Below examples of those several films are presented to describe emotions revealed by using the primary colors:

- *Ex Machina* - the red color filling the whole frame shows violence and anger which dominates in film. The encompassing red glow signifies a fresh intensity and serves as a cue for the audience to pay attention because something crucial is about to happen. On the other hand, the use of red color in film such as *American Beauty* emphasizes the love, passion, and romanticism of heroes.

- *Mad Max: Fury Road* – the orange color is often associated with warmth, energy, and humor, but just as a red color has a twofold meaning. It can strengthen the hopeless and tragedy situation.

- *Hotel Chevalier* – director Wes Anderson focused on highlighting the yellow color to show happiness, the feeling of relaxation. However, in *Birdman,* the yellow color shows jealousy or betrayal.

- *Only God Forgives* – the blue color emphasizes in isolation of the character from reality and sterility of his emotions, but on the other hand, is associated with loyalty, trust, and inheritance. *Midnight Special* – faithfulness, loyalty, and childlike wonder are shown in the Jeff Nichols' science-fiction film. The main character is one-of-a-kind in every sense of the word and is covered in blue from head to toe. Used here, this color is associated with positive thoughts, innocence, and purity.

- *The Mechanist* – mundane and dull everyday repetitiveness is put on full display with dreary green colors and lifeless image. A green overtone always works for the examination of monotony. This can also be seen in *The Matrix.*

- *Lost River* – some scenes in this film are engulfed by a purple backlight, exposing sultry hero silhouette and immediately notifying the audience of her mysterious nature. Purple is often associated with ambiguity and extravagance, but using it appropriately can yield striking imagery – *Guardians of the Galaxy.*

- *The Grand Budapest Hotel* – soft pink motif for the shop in Anderson's film shows childlike romance between two characters. In *It Follows* the main character, who wears a pink outfit in a room filled with pink represents her innocence and purity. Violet, magenta, light pink, all of those colors can be associated with romance, love, and passion.

IV. OBJECTIVE COLOR MEASURES IN THE FILM

This study also proposes a methodology for defining the most dominant color in the film scene. In the literature, there exist some propositions for objective color measures:

- Changing color of shots – the difference between dark and light elements in the shot.
- Frequency of occurrence of color in the shot – determining the most dominant color in the scene.
- Film color palette – changing the most commonly used colors in the film.
- Mood dynamics – determining transitional colors between shots in the film.
- Tempo – determining the number of frames in a given shot.

By preparing an appropriate algorithm (see Fig. 1), it is possible to determinate the most dominant color in the film and background colors, and on this basis, assign emotions to them. However, it is necessary to analyze the whole palette of colors; one color is not sufficient to reflect the emotions of a given fragment of the film, the entire palette of a given scene should be analyzed.
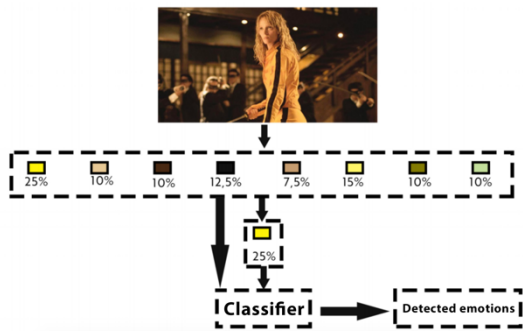
Figure 1. Proposition of emotion classification algorithm.

V. EMOTIONS IN FILM MUSIC

A. The importance of music in the film

Music in film production is not only behind the stage element, but it is a filler for the whole story presented by the director, i.e., it is an integral component of the film. It can characterize the hero, the mood of hero or scenery, build the tempo of action or calm a viewer, but it can also contribute to the augmentation and intensification of feelings.

Film music can be divided into several types. Even though the genre of the film determines the genre of music; it needs to be remembered that the film is a work created from image and sound. The process of its creation assumes the simultaneous complementation of these two means of expression. A composer with some advice from the director creates music to ready-make and edited film. The main task of film music is to express the climate of the movie, its characters and how emotions are contained in the scene, that function of film music enables the viewer to participate in hero's story.

The analysis of film music takes into account both low- and high-level parameters. This will enable to define the emotions contained in the film and align them with the most dominant colors in the scene to create a more accurate combination of both [7].

Examples of high-level parameters [8]:
- Rhythm – tempo;
- Harmony and tone;
- Melody;
- Dynamics.

Examples of low-level parameters [8]:
- Audio Spectrum Envelope – it is a short-term spectrum of power density determined for frequencies at logarithmic intervals.
- Audio Fundamental Frequency – basic frequency of a track measured in Hz.
- Harmonic Spectral Centroid – defined as an amplitude weighted of the average frequency of the bands in the spectrum.
- Harmonic Spectral Spread – defined as a measure of the average spread of the spectrum in relation to its centroid.

VI. MOOD MODELS

Several models of emotions were defined in the literature based on the number and groups of verbal descriptions [9],[10],[11]:

- Hevner's model – consists of sixty-seven adjectives of emotions, which are grouped in eight different clusters. Each cluster contains adjectives that are close in meaning, and the adjacent clusters differ slightly.

- Thayer's model – it is another two-dimensional arousal model. Thayer divides a 2D emotion space into four quadrants, separated by orthogonal axes of stress and energy. Also, in each quadrant, representative emotions are assigned, such as content, anxious, depressed, and exuberant. This model does not have a high number of well- defined different emotions, but on the other hand, it is more straightforward in use. The central aspect of the model is that emotions are situated far away from the center. In the center, arousal and valence have small values, and these adjectives do not represent clear and identifiable emotions.

- Plutchik's model (Fig. 2) – this model contains the eight primary emotions, which are the basis for all others, are grouped into polar opposites: joy and sadness, acceptance and disgust, fear and anger, surprise and anticipation.

A well-designed movie color palette evokes mood and sets the tone for the film. Filmmakers should understand color theory norms but never seen it as a limitation. Color theory for filmmakers is presented below in a tabular form (Table I), where the names of colors with matched emotions are contained. These are the most popular color in the film to create certain emotions in the viewer by the filmmaker [4].

Figure 2. Plutchik's mood model.

TABLE I. MOVIE COLOR PALETTE WITH MATCHED EMOTIONS

Color	Emotion	Color	Emotions
	Warm Colors		*Cold Colors*
Red	Love	Green	Nature
	Passion		Immaturity
	Violence		Corruption
	Danger		Ominous
	Anger		Darkness
	Power		Danger
Pink	Innocence	Violet	Fantasy
	Sweetness		Ethereal
	Feminity		Eroticism
	Playful		Illusory
	Empathy		Mystical
	Beauty		Ominous
Yellow	Madness	Blue	Cold
	Sickness		Isolation
	Insecurity		Cerebral
	Obsessive		Melancholily
	Idyllic		Passivity
	Naive		Calm
Orange	Warmth		
	Sociability		
	Friendly		
	Happiness		
	Exotic		
	Youth		

VII. SUBJECTIVE TESTS

A. The methodology of the subjective tests

To assign specific emotions from the film shot in terms of color to their reception, three separate subjective tests were carried out. The first subjective test consisted in determining which model of emotions out of the three given is the most convenient for describing emotions resulting from colors chosen by filmmakers and the most dominant colors in the selected film scenes. Ten different shots were selected for the test, in which a most dominant color scheme characterizes them, each shot lasts 45 - 60 seconds. A person taking part in the test, after seeing each shot, should mark on the graph presenting the given emotion model the three emotions which, according to him/her, were included in the given approach to emphasize emotion contained. Five different scenes of the film were selected for this test. The movie scenes selected for subjective tests are the ones of the most popular films of the last two decades, which are mainly characterized by the color scheme of the shots. The directors chose the color of the movies based on the psychology of color according to the content presented in the picture.

While conducting the second subjective tests, the participants were also asked to specify three emotions which, according to them, the director tried to present in the film scene. This should be introduced on the particular graph depicting the model of emotions. The length of the scenes was chosen between 45 to 60 seconds; the respondents had to determine the emotions for each of the five scenes. The film scenes were selected from the most popular film productions and in the first part of this subjective test, they were presented without the accompanying soundtrack also containing music.

The third part of subjective tests included the same test scheme as before, but the participants of the test were assessed the three emotions of the scene of the same films, which were – this time - accompanied by the soundtrack.

B. Results of the tests

1) Choosing the most accurate model of emotions.

From five different shoots for each mood model (Hevner's, Thayer's, Plutchik's), three most meaning emotions chosen by participants were selected from the answers. The results are gathered in Tables II, III, and IV, respectively.

TABLE II. SELECTED EMOTIONS ASSIGNED TO THE FILM SCENE – HEVNER'S MODEL

Title of the film – scene	Emotion	Color of the shot	Votes [%]
American Beauty – lovely dream	Dreamy	Red	82.5
	Passionate		82.5
	Tender		62.5
Grand Budapest Hotel – pink box	Dreamy	Pink	72.5
	Passionate		62.5
	Tender		42.5
Guardians of the Galaxy – power stone	Majestic	Purple	75.0
	Passionate		67.0
	Dreamy		60.0
Birdman – verbal fight	Scared	Yellow	85.0
	Sad		62.5
	Dramatic		55.0
Only God Forgives – mirror	Depressing	Blue	87.5
	Gloomy		67.5
	Dark		35.0

TABLE III. SELECTED EMOTIONS ASSIGNED TO THE FILM SCENE – THAYER'S MODEL

Title of the film – scene	Emotion	Color of the shot	Votes [%]
American Beauty – lovely dream	Happy	Red	100.0
	Exited		75.0
	Pleased		57.5
Grand Budapest Hotel – pink box	Happy	Pink	100.0
	Pleased		82.5
	Exited		42.5
Guardians of the Galaxy – power stone	Nervous	Purple	100.0
	Angry		80.0
	Annoying		50.0
Birdman – verbal fight	Nervous	Yellow	95.0
	Angry		82.5
	Sad		77.5
Only God Forgives – mirror	Sad	Blue	100.0
	Annoying		82.5
	Bored		72.5

TABLE IV. SELECTED EMOTIONS ASSIGNED TO THE FILM SCENE – PLUTCHIK'S MODEL

Title of the film – scene	Emotion	Color of the shot	Votes [%]
American Beauty – lovely dream	Love	Red	100.0
	Admiration		70.0
	Joy		67.5

Grand Budapest Hotel – pink box	Love	Pink	100.0
	Admiration		65.00
	Joy		60.0
Guardians of the Galaxy – power stone	Fear	Purple	67.5
	Anger		57.5
	Awe		37.5
Birdman – verbal fight	Sadness	Yellow	82.5
	Fear		75.0
	Apprehension		62.5
Only God Forgives – mirror	Sadness	Blue	100.0
	Boarding		72.5
	Pensiveness		52.5

2) Assigning emotions to the film scene without sound path

In Table V, the results of the 2nd test are shown. As seen in Table V, some of the emotion assigning tasks were easy, and some were more difficult for the testers.

TABLE V.   SELECTED EMOTIONS TO THE FILM SCENE WITHOUT THE SOUND PATH – PLUTCHIK'S MODEL

Title of the film – scene	Emotion	Color of the shot	Votes [%]
Glorious Bastards – make up the scene	Love	Red	92.5
	Ecstasy		52.5
	Optimism		47.5
Kill Bill – car fight	Surprise	Yellow	100.0
	Anger		65.0
	Aggressiveness		60.0
Ex Machine – discussion	Fear	Red	67.5
	Anger		57.5
	Awe		37.5
Only God Forgives - contemplation	Sadness	Blue	87.5
	Pensiveness		57.5
	Boredom		42.5
Grand Budapest Hotel - conversations	Trust	Orange	75.0
	Optimism		62.6
	Admiration		35

3) Assigning emotions to the film scene with the sound path.

In Table VI, the results of the 3rd test are shown. Comparing results contained in Tables II and III, it may be observed that viewers had fewer problems with identifying the right emotion when soundtrack accompanied the given scene.

TABLE VI.   SELECTED EMOTIONS TO THE FILM SCENE WITH THE SOUND PATH – PLUTCHIK'S MODEL

Title of the film – scene	Emotion	Color of the shoot	Votes [%]
Glorious Bastards – makeup scene	Love	Red	100.0
	Optimism		47.5
	Serenity		40
Kill Bill – car fight	Anger	Yellow	100.0
	Rage		60.0
	Aggressiveness		55.0
Ex Machine – discussion	Anger	Red	100.0
	Rage		80.0
	Annoyance		42.5

Only God Forgives - contemplation	Sadness	Blue	95.0
	Pensiveness		52.5
	Boredom		35.0
Grand Budapest Hotel - conversations	Trust	Orange	82.5
	Optimism		55.0
	Admiration		52.5

VIII. ANALYSIS AND DISCUSSION

Further on, analysis of variance (ANOVA) was performed (see Table VII). The test results indicate that the differences between the groups of correct answers (at $p<0,05$) are statistically significant. The test participants' responses were grouped against the correct ground truth responses, for which the psychology of color for filmmakers was adopted.

TABLE VII.   RESULTS OF THE ANOVA TEST

Source	SS	df	MS	F	Value p	Test F
Between groups	73.01	2	3.50	17.58	0.00	3.07
Inside groups	24.85	117	2.07			

In addition, in the first phase of carried out tests, participants were asked to indicate whether the emotion models give the same opportunity to describe the emotions that are prescribed in film scenes. Thirty-six test participants pointed out that Thayer's emotion model had too small a set of adjectives to determine the emotions fully. The circle of emotions of Plutchik's model makes it possible to distinguish between eight families of emotions. Besides, derivatives are defined between these groups, for example: for joy and acceptance, the resultant emotion is *love*. For this reason, this model of emotions was employed for further analysis of subjective tests. For this purpose, the groups of responses from Hevner's and Plutchik's models were compared with the use of the Student's t-test. The results of the analysis are presented in Table VIII.

TABLE VIII.   RESULTS OF THE STUDENT'S T-TEST

	Hevner's Mood Model	Plutchik's Mood Model
Mean	9.95	10.75
Variance	2.025	2.19
Observations	40	40
df (degrees if freedom)	78	
t Stat	-2.28	
p (T <= t)	0.0097	

For the null hypothesis accepted: each of the two models is suitable for describing emotions that are contained in an appropriately colored film scene. An alternative hypothesis is as follows: one of the models is better to describe the emotions contained in the correspondingly colored scene than the others. The Student's t-test result is significant at $p <0.05$; we can reject the null hypothesis for an alternative hypothesis. Looking at the

average number of correct answers with regard to the ground truth, it can be assumed that Plutchik's model is better suited for discerning emotions in film scenes.

The second analysis of the Student's t-test was aimed at showing the result of better effectiveness of emotion recognition from the film scene when the soundtrack is accompanying the scene and marking it on Plutchik's emotion model; while the alternative hypothesis assumes that there are no significant differences between the emotion displayed, provided by a fragment of a film without soundtrack as well as with soundtrack. Table IX shows the results obtained.

TABLE IX.   RESULTS OF THE SECOND STUDENT'S T-TEST

	Hevner's Mood Model	Plutchik's Mood Model
Mean	9.425	9.975
Variance	1.38	1.61
Observations	40	40
df (degrees if freedom)	39	
t Stat	-2.56	
p (T <= t)	0.0072	

The Student's t-test result is significant at $p < 0.05$; we can reject the null hypothesis for an alternative hypothesis. Based on the mean value obtained, it can be concluded that the persons participating in the test could more effectively determine the correct emotions contained in the film scene when a scene was presented with the soundtrack. Based on the third test, where the original soundtrack was also included, participants often chose the same emotions, or there was a change of choice by taking into account emotions that were selected more often. For example in *Glorious Bastards* film with a makeup scene *love* with 92.5% of votes was chosen in the second subjective test as the main emotion, but in the third subjective test, the same emotion gathered 100% of votes. In a scene from Ex Machine film, where the most dominant color is red, 100% of votes are for *anger* according to Table VI. This is another case where the soundtrack of a film influenced the change in the feelings of testers. Almost in all cases regarding the color theory and emotions for filmmakers, most of the emotions from subjective test coincide with emotions chosen by persons participating in the test.

IX. SUMMARY

Subjective tests carried out for defining which of the mood models known in literature is the most appropriate, allow answering this question. Form the results obtained; it is seen that Plutchik's mood model is a very convenient way to assign color to emotions in the film scene. Moreover, the tests confirmed that when creating a system for automatic film grading, music accompanying a movie should be taken into account. Therefore, several high- and low-level music signal parameters were recalled. They were already checked by the authors [12], and they proved to discern between emotions contained in a scene. Moreover, assumptions for detecting emotions in the video shots based on color retrieving were also given in the paper.

The next step of this research study is to gather a database of annotated (in the context of emotions) scene shots and perform automatic color grading classification based on color scheme and music contained in the soundtrack with the use of machine learning.

Also, several other issues may be checked, e.g., to what extent the content of the scene affect emotions and what are the dependencies between content, color, and soundtrack. For that purpose, a dataset appropriately annotated by the viewers should, however, be used. Moreover, it would also be interesting to study whether and if yes to what extent human emotions can be controlled using image and sound.

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