A Critical Analysis of Facial Animation Based On Emotional Condition and Facial Skin Colour

Mohammed Hazim Alkawaz, Ahmad Hoirul Basori and Dzulkifli Mohamad

Abstract— The research on facial animation has grown very fast and become more realistic in term of 3D facial data since the laser scan and advance 3D tools can support creating complex facial model. However, it's still lacking in term of facial expression based on emotional condition. Facial appearance changes as people talk, move and, change expression. The key indication of this change is the skin colour. Facial skin colour is one parameter that is contributing on augmenting the realism of facial expression, because it's closely related to the emotion which happens inside the human. This paper describes facial animation and the emotion that is related to the facial skin changes like blushing, anger or even sadness.

Index Terms— Facial Animation, Emotion Colour,Emotion Theory and Facial Expression.

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1 INTRODUCTION

FACIAL Facial Animation is the main element to express emotion and personality. Computer facial animation has many applications in different aspects, e.g. realistic virtual humans with various facial expressions used in the industry of entertainment and edutainment. In communication applications, it can improve the interaction between users and machines by using interactive talking faces, and can also attract users by providing a friendly interface. Fred Park 1974 was the first who showed interest in facial animation. He is also the first who used the power of 3D computer graphics in a way that delivered the highest level of control that drives the acts of a face. Applications at that time included computer generated actors and a rich research instrument for those studying the field of non-verbal communication and human facial expression.

As the online game manufacturing develops fast, it requires users to improve, greater quality of the graphics, and to achieve a significant feat in artificial intelligence. These elements motivated the gaming industry full with priceless artificial intelligence and graphics like real photos. Initially, the games consisted few number of polygons in characters and were supported by a few active computers in that regard. Presently, the characters in the game appear to be more natural, but there are still challenges in expressing the emotions of characters in a detailed way. However, several colour model researches were only capable of proposing the facial colour model [1-3] that are based on pulse, skin temperature and real human blood flow.

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These mentioned techniques end up conveying the colour of the face with an increasing redness [4].

2 RELATED WORK

The recent development in digital technology has stabilization in high-speed processing of great quantities of information. Therefore, applications used for long-distance communication such as Conferencing and video telephony are being constantly developed. A distinct element that showed the advanced communication prowess of these systems is the presentation and estimation of emotions using the color of the face as well as expression. In candid terms, if the color of the face changes, emotional changes that are related can be used for the fusion of the facial expression to change the basic emotions of visual anthrop orphic agents; this may likely play a key role vetting communication between computers and humans.[1].

Facial colour of humans would be channeled to display the virtual effect, emotional estimate, facial image, remote health care, and individual identification. In which it can be regarded as one of the "the most peculiar and the most human of all expressions"[5] ,blushing is a common topic of psychological study, it has been evidenced to be an important facial cue which serves vital functions in interpersonal communication [6] . The explanations of why people blush is still an issue among psychologists. Most people consider blushing in public as an uncontrollable response and most people feel embarrassed when they blush in front of others. Furthermore, blushing is a symptom that made it even worse for people who suffer from social phobia [7]

While pallor effects occur through temporary cerebral anemia and contractions of the treatment capillaries in the face due to the rising of cerebral blood flow. Pallor perhaps happens Couse to fear pain, or shock. This action decreases the blood flow in the face and forwards it to the

brain for relief and recovery. In the literature that was researched, the measurement of pallor was not found. Psychophysiological analysis of pallor is likely to provide known results because the red areas are more likely to show pallor and the time pattern of pallor. However, we have a formal monitoring that shows that the pallor has gained far less attention in the psychophysiological analysis compared with redness. The central component of the computer model that is of interest is the identification of the main characters that reflect this phenomenon. We consider the emotions of the blood vessels and skin color, accent sets occur [2].

Former studies focus mainly on the geometric features of these alterations, for instance, the facial surface animation (e.g. skin stretching, wrinkle structures). Similarly, changes in hemoglobin concentration cause changes in skin color. It can also be caused by the reaction of histamine or other skin conditions for example blushing and rashes. Blushing specifically consists of a number of emotions such as joy, shame, and arousal. Regardless of their ability to convey emotion, the dynamic changes that occur in skin pigmentation are mostly ignored by present skin appearance models [8, 9].

Reasonable behavior and realistic appearance is essential for simulating communicative behavior. Postures and simulation also reflect the emotional behavior. Several models of emotions exist, the psycho-evolutionary theory was developed by Plutchik[10] and the FACS by brought up by Ekman. However, the vast of these models are merely appropriate for muscular expressions. Nevertheless, in graphics too, the change in colour is a less control field. Moreover, other physiological features such crying will not be undertaken. Blushing effects as shown in [2] can occur when there is a very intense sensation [11].

The most frequently affected parts are the cheeks; there is a relationship between temperature increase and blushing [11, 12]. The usual blushing starts at 35s with the highest intensity after 15s. The face and Ear blush likewise. Blood flow reduction causes Pallor [2] e.g. causing fear. Parts that blush may also become pale. Sweat and weeping (sometimes accompanied by blushing) can be considered as vegetative functions that are controlled by the autonomic nervous system (ANS) [11]. Surprise, fear and happiness are accompanied with very light colors. Sadness and disgust usually with colors of medial lightness, and anger is mostly associated with dark. Colors associated with fear and sadness are actually desaturated (close to 0, 0), whereas surprise, happiness and anger are related extremely to chromatic colour [13].

The skin of the face is rich with vessels. A vast quantity of blood vessels and a high level of activity in the facial skin by the enzyme may reflect the high metabolic activity. There are many kinds of formal subsidiary in the face. In [2, 14] conducted a study of vascular patterns in the skin in different areas of the face. The region based approach highlighted that areas like the nostril and forehead have bilateral divisions at sharply acute angles called "fronds," And areas such as cheeks and jaws from one side branching nearly at right angles is called "candlestick".

Some areas show in-between types of subsidiary between the "frond" and "candelabra." Numerous areas portrayed several forms in the capillary stream to the skin. There are many regional varieties and any one region varies greatly according to the individual, especially with the age component. These differentials may highlight why certain areas show more external activity than others. For example, the redness may is seen more on the cheeks, ears and forehead rather than the rest of the body [2]. Refer to Table 1

Overview of visually distinguishable emotional states caused by vegetative functions, used for the parameterization of emotions that result in different facial complexions [11]

TABLE 1. EMOTION AND CHANGE IN FACE [11]

EMOTION	FACIAL APPEARANCE VARIATION
Neutral	No changes, neutral face color
Joy	Cheeks become Rosy
Enthusiasm/ Ecstasy	Cheeks become Rosy, tears of happiness
Surprise	Cheeks become Rosy
Disgust	Cheeks become Pale
Down	Low watery
Sadness	Cheeks become blushing, raised lacrimation
Grief	Cheeks become blushing, blotchy red and intensive lacrimation
Apprehension	Cheeks become Pale
Fear	The whole face is pale
Panic	Face becomes Pale, sweat on the forehead, low lacrimation
Annoyance	Cheeks become blushing
Anger	Cheeks become blushing, blotchy red in the face
Rage	Cheeks become blushing, blotchy red in the face, the face is red

Fig. 1. The first three images showed anger, hence the cheeks are blushing and then red blotches appear. The fourth image showed weeping badly and also the cheeks blushing. In the last three images after positions and colours have been changed, droplets appear and effects like perspiration or nose bleeding can also be simulated [11].

When joining facial expressions with color skin (Fig.1). Corresponding emotion is easier Perceivable and more plausible for strong emotions. The changes for skin can be managed according to a parameterized emotional model. A group of possible skin alterations on the physiological and psychological knowledge was carried out in order to explain the model. The combination of droplet flow and color change can be used to provide a convincing real world emotion. [11].

The animated facial models [15, 16] are not just less expensive when compared to human performers, nonetheless they are more elastic, which offers alterations in style and appearance. These advantages can provide users with alternatives to substitute computer generated models with human actors. Several ways are used to achieve 3D or 2D models in animation. A software modeling tool can be used to generate it manually, by capturing it from a 3D clay model with a digitizing pen, which is attached to a mechanical arm which will calculate the location of the tip of the pen; or took from an actual human by cameras or other scanning technology. The obtained 3D data is further parameterized into a mathematical representation as in splines, implicit surfaces or polygonal models, and then it can be manipulated using the computer.

3 EMOTION COLOUR

An emotion is a complex state of mind which includes physiological correlates, cognitive factors and social roles. Emotions provide a person with the energy for a reactive behavior which cam delay and thus control the actual response. Some emotions are regarded basic, as they cannot be reduced to others, and their external appearance plays a crucial role in social adaptive interactions. Basic emotions seem to be profoundly universal, and their external expression appears to be independent of personal experience and culture. Thus, they can be exposed by facial expressions without the interference of verbal language. Six basic emotions that correspond with facial expressions have been recognized: anger, sadness, happiness, surprise, disgust, and fear. Exposure of one's emotional state by facial expression can be unintentional but, somewhat, it is possible to practice on conscious control of facial expression to serve certain social goals [13].

As stated by Michael Argyle, 'the final verdict is that facial expressions are partly deliberate social signals, but that they also reflect true emotional states. Emotional states are obviously signaled through facial expressions, but the color changes of the human face also has a limited range; emotions are usually accompanied by a decrease or increase of blood flow to the face leading to pallor or blushing. John Berendt [17] gives an rare example of an instance where face color was more expressive than facial expression as an emotional state indicator. In his explanation of the fire that devastated the Fenice Opera House in Venice, and the following court proceedings, Berendt describes a significant feature of the prosecutor Felice Casson (p.79), he states "It was his tendency, when he was angered, for his face to turn pink, then red, then scarlet, from the top of his forehead to the neckband of his collarless shirt" [13].

To provide the viewer with information about the nature of objects is a central role of colors. They can also stimulate the viewer to respond to a group of circumstances in a certain way. Amongst the noticeable characteristics of objects, the negative and positive values can be counted for the observer. If facial expression creates a pre-language way of communication, it might be likewise for color with the possibility that colors, like facial expressions, can be related to emotions. There is a great deal of proof that the connection between emotions and colours is attributed to human biology.

Blushing and turning pale may be part of the process, but the variety of colors that can express emotions is more than pink to scarlet presented by Felice Casson. Thus, some correspondence rules between emotions and colors can be defined [13].

Pos and Green-Armytage examined whether the pairing of emotional facial expressions with colors is reliable among various cultures, particularly between European and Australian people. Two experiments were held consisting of two groups, one mainly of younger and the other of older people as participants in the process. Single colors and combinations of three colors were chosen for each of six faces, that expressed the basic emotions anger, sadness, happiness, surprise, disgust, and fear, to achieve the best visual 'fit' with these faces. The two groups performed in an identical way basically. The emotions appear well distinguished by the paired colors. For analyzing the results of the experiments two approaches were utilized: the first uses techniques from the psychology discipline, the second from the discipline of design. The mentioned six emotions were related with regard to each colours position in the CIELAB (CIELAB is the second of two systems adopted by CIE in 1976 as models that better showed uniform color spacing in their values) the warm/cold characteristics, color space, and the distinction between the three colors of the triplets.

The process in which facial expressions were 'translated' into colors and colors into faces could also be established. By examining the successes and failures in communication; single colors and color combinations for each face that could be labeled as 'correct' and which can function as a guide for designers could be possibly proposed [13].

4 EMOTION COLOUR IN AVATAR

The researchs' literature is built on certain areas, first, part of it is from history with Goethe and his colour theory, then an overview of color-meaning from Cluadia Cortes, then it was followed by a user test conducted by Naz Kaya, then the view of a Shirley Willett, which is a commercial product Colour Wheel Pro used for designing websites, and finally a small process example from Yan Xue.

4.1 Johann Wolfgang von Goethe

In his work "Colour Theory", there are many remarkable parts he stated considering the meaning of colour particularly in part six "Sinnlich-sittliche Wirkung der Farbe". He categorizes colors into a minus part and a plus part. The positive part or plus part are the colours yellow, red-yellow (orange) and yellow-red (vermeil), these colors represent arousing, lively and ambitious (regsam, lebhaft, strebend).The negative include the colours blue, blue-red and red-blue, which represent restless, yielding

and yearning (unruhigen, weichen undsehnenden Empfindung). Table 2 gives a summary of colour meanings from Goethe. The precise translation of each color [18].

TABLE 2. Colour J.W. Von Goethe Colour Summary

Emotion	Negative trait	Positive trait	Colour
calm		neutral ,calm	green
same as red blue, but more negative	more restless	more active	Blue-red
faith		charm/grace dignity, seriousness,	red
joy	unreinen", Green) unpleasant	purity pleasant	yellow
powerful	irritating	energetic,	yellow-red
happiness		Warmth, energetic, passive	red-yellow
discomfort	restless	active	red-blue
sadness	Void cold	comfort	blue

4.2 Claudia Cortes

Research done by Claudia Cortes provides a widespread list of characteristics of positive and negative traits. It does not just sum up some emotions for a particular colour, but as well what is usually related with the colour. This though makes it tough to abstract the different colors into their greatest intense emotional meaning. Yet it has impressively influenced the selected emotion meanings and location onto the special grid (which is the central part of the model). A summary of the traits presented on her page can be seen in table 3. It does not show all the traits; it only shows those which overlap with other used sources, visit for a complete list [18].

TABLE 3. Colour Claudia Cortes Colour Extraction

Emotion	Negative trait	Positive trait	Colour
melancholic, introspective	sorrow, arrogant	passive, leadership	Purple
greed, faith	sick, greedy	Neutral,calm	Green
sadness, confident	depressed	traditional, faithful	Blue
anger, love	embarrassed, offensive	emotional, active	Red
Happiness/joy, fear	cautious	energetic, lively	Yellow
determination, joy	tiring	Ambition	Orange

This is a very small part of her site, and it includes merely the information that is used in the proof of the

concept. Information about symbolism can also be found on her page.

4.3 Naz Kaya

Naz Kayas' research shows the difficulty in stating things about colours and how to interpret them. The tests' results were presented in a frequency table. The emotion - colour combination with the peak overall score was taken

TABLE 4A. Colour Naz Kaya Color Summary

Emotion	Colour with Munsell notation
annoyed, disgust	Green-Yellow (2.5GY 8/10)
Tired	Purple (5P 5/10)
no emotion, excited, energetic	Yellow-Red (5YR 7/12)
loved, anger	Red (5R 5/14)
peaceful, hopeful, comfortable	Green (2.5G 5/10)
Happy	Yellow (7.5Y 9/10)
Calm	Blue (10B 6/10)

TABLE 4B. Colour Naz Kaya Colour Summary

Emotion	Colour with Munsell notation
powerful, fearful, depressed	Black (n/1)
peaceful, lonely, empty/void, innocent	White (n/9)
depressed, confused, bored, sad	Gray (n/5)
sick, confused, annoyed	Blue-Green (5BG 7/8)
no/emotion, loved	Red-Purple (10RP 4/12)
powerful, calm	Purple-Blue (7.5PB 5/12)

from the test into table 4A and B [18].

It has to be noted that some frequencies for certain emotion colour combinations came very close together; thus, they are both added into the table. It is mentioned in the table header the Munsell color system or the Munsell colour tree which is an industrial standard that describes colors in a 3 dimensional way <hue, chrome, value> as seen in Fig. 2, and is perhaps the most common used colour system. Colour Wheel Pro is a well-known product based on this system.
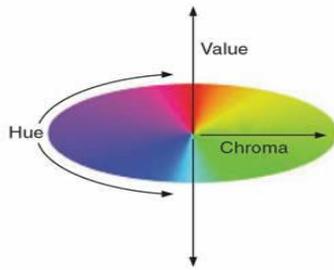
Fig. 2. TheMunsell colour space [18].
The Munsell Colour system is based on the Newton colour circle

4.4 ColourWheel Pro

The commercial program Colour Wheel Pro also defines what certain colours are to us. According to the color theory they give a professional method of mixing colours taken from their web-page the following Table 5 is produced, concluding the meaning of colors [18].

TABLE 5. COLOUR WHEEL PRO COLOUR SUMMARY

Emotion	Negative trait	Positive trait	Colour
power	death	elegance	Black
sadness	frustration	romantic, nostalgic	Purple
(not given)	Power	safety, purity	White
aggressive/anger, intense, emotionally	Courage, offensive	passion	Red
joy, happiness	jealousy, sickness	freshness	Yellow
joy, happiness	distrust,domination	desire, wisdom	Orange
greed	sickness, disorder, envy	growth, good health	Green
trust	depression	understanding	Blue

Note on the summary, this is a short list; there are some of the traits that overlap with each other and other that are even dubious about their precise meaning (if its more context depended). A suitable word was chosen which corresponds with it the most by looking at the given meaning of a colour.

4.5 ShirleyWillett

The following is a table of colors with their properties defined by Shirley Willett, the presented model is used as a standard for the basic emotions with their colors. Willets' model presented in (Fig. 3) overlaps with the data found from Claudia Cortes work but it differs from it only that it reduces the list to the basics.

Fig. 3. Shirley Willett, Colour codification of emotions.
The external circle consists of the positive traits, the second circle contains the six emotions, the inner circle presents the negative traits, and the central spot is depression which has been chosen by her as being the combination of all negative traits. The information is also presented in table 6 [18].

TABLE 6. COLOUR SHIRLEY WILLETT COLOUR TABLE SUMMARY

Emotion	Negative trait	Positive trait	Colour
power	impotence	leadership	Purple
greed	hoarding	satisfaction	Green
confusion	racing	Clarity	Blue
anger	rage	enthusiasm	Red
fear	panic	awareness	Yellow
shame	disgrace	Pride	Orange

4.6 Yan Xue

Yan Xue devotes a few words on the utility of colour support in his master thesis on the Philips ICat. The ICat can use particular colours (blue, red, green), these colors are produced by colour LEDs positioned in the feet and the ears. Though he did not talk much about these colours, he makes a central use of the so called warm/cold colours and designed a model with these colors. He used Russels circumflex model as a basis as shown in Fig 3 [18].
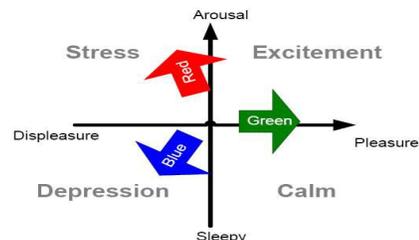

Fig. 4. Yan Xue colour distribution[18].

4.7 Comparing the Different Models

The information collected from this literature research is intensely extracted in such a way to make it beneficial in the proof of concept. The rate of color meanings is large

which makes it hard to deal with. The most important part is the research done by Naz Kaya, which delivers a good view on what meaning colours can imply. Claudia Cortes' work supports it for it constrains almost all parts of the results into the basic colours. However Goethe's work is uneasy to apply, it has some of truthful to certain degree but it is difficult to confirm. Nevertheless, Shirley Willets model displays a solid model providing clear answers to what a colour can be. Finally the model by Yan Xue presents a simplistic way of interpreting the three basic colours RGB. One item is surprising; it does not have a colour. Despite that "surprise" is a basic emotion (as Ekman says) it is not clearly stated with a colour [18].

5 CONCLUSION

Virtual human, has been developed in various forms of computer applications. Currently, an avatar is able to interact naturally depending on the considerable progress in artificial intelligence, diverse sensing technology and advanced computer graphics. Facial animation is used in a large number of critical areas. It helps to bring humanity facts and representations of expressions to the reality of human, social reality and more significantly in the expression of many computer games most effectively, the field of medicine, interactive through multimedia and movies, and began to grow and increasing significantly in terms of importance and widely usage. In this paper, we explain the diverse and often overlapping categories of facial animation, covered the emotion colour and we mention on emotion colour in avatar. Finally compare the different model of colour.

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