

# A Study on Character's Emotional Appearance in Distinction Focused on 3D Animation "Inside Out"

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## 3D 애니메이션 "인사이드 아웃" 분석을 통한 감성별 캐릭터 외형특징 연구

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**Abstract** This study analyzes into the characteristic appearance in distinction with emotional changes toward visual forms of psychology along with character development in the 3D animation industry. In this regard, the study seeks to propose essential targets of the five emotional characters from the Pixar's animation Inside-Out to prove psychological effects to the character's visual appearance. As a previous research, the study analysis the visual representations oriented toward both emotional facial expression and emotional color expression using both Paul Ekman and Robert Plutchik's human basic emotion research. The purpose of this study is to present the visual guideline of emotional character's appearance through the various human expression for differentiated character development in animation production.

**Key Words** : Characteristic Appearance, Character Development, Visual Forms of Psychology, Emotional Facial Expression Change, Emotional Color Expression

요 약 본 연구는, 발전하는 3D 애니메이션 영상산업의 캐릭터 개발과 관련하여, 심리변화를 중심으로 감정의 표현 방법을 위한 캐릭터의 외형별 특징 분석에 대한 연구로, 2015년 픽사의 인사이드 아웃을 중심으로 심리의 시각적 형태를 위한 5명 캐릭터의 감성별 외형 특징을 대상으로 분석논문을 진행하였다. 이를 위해 선행연구로 인간의 심리적 범주의 변화를 심리학자 Paul Ekman과 Robert Plutchik의 기본감정을 연구배경으로 선택, 이를 바탕으로 애니메이션 인사이드아웃 속 사춘기 소녀의 심리요소를 대표하는 다섯 캐릭터의 외형적 특징 요소를 감성별 표정변화와 감성별 색상변화를 심리적 관점에서 접근, 시각적인 표현의 방식에 대하여 분석하였다. 본 연구는 3D 애니메이션 제작과 관련하여 감성 표현을 통한 캐릭터 설정에 필수적인 외형 특징 연구가 필요하다고 판단, 향후 애니메이션 제작을 위한 차별화된 캐릭터 설정 및 개발에 필요한 가이드라인을 제시하는 것에 본 연구의 목적과 의의를 두었다.

주제어 : 캐릭터 개발, 캐릭터의 외형, 심리의 시각적 형태, 감성별 표정변화, 감성별 색상변화

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## 1. Introduction

### 1.1 Research Background

As modern 3D animation entertainment became a major culture industry, the scale of 3D animation industry has been rapidly growing every year. Since the peak in the sales of Disney's "Beauty and the Beast" and "Lion King" recorded in the previous traditional 2D animation, both animation movies of Pixar's "Toy Story" and DreamWorks' "Shrek" became the catalyst which conduced a breakthrough the limit of world's sales record in 3D animation's industry. According to the IMDb<sup>1)</sup>, Pixar's "Toy Story" earned a half a billion dollar sales revenue since its opening from 1995, furthermore Pixar's recent animation "Inside Out" has earned almost an one billion dollar sales revenue since 2015. There are several factors increasing audience's visual immersion from 3D animation producers by researching both storytelling to character theme and character's emotional appearance in distinction.

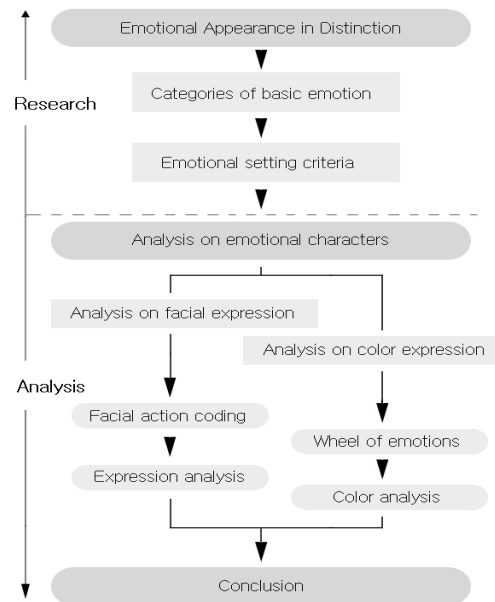
Therefore, this analysis study aims to present the necessary reference guideline for the advanced character development by comparing the features of the emotional appearance through the facial and color expression to represent the five emotional characters from 3D animation "inside out".

### 1.2 Scope and method of research

In order to define characteristics of personality by analyzing characters, this study investigated to classify the categories of basic emotions and research method for emotional setting criteria within the significance of characters in 3D animation. Then the study conducted in the order of analyzing and verifying the features of two key visual elements of character's facial expression and color expression based on the aspect ratio and shape from the five psychological characters.

For the reference, the study mainly focused on the analyzing the core visual expression of the psychological emotions in five main characters based on still frame images form excluding the motion of their animation.

The following [Fig. 1] is a brief summary of the scope and method of the research through the overall analysis study.



[Fig. 1] Research procedure

## 2. Significance of emotional characters

### 2.1 Categories of basic emotion

Psychologist Paul Ekman<sup>2)</sup> categorized six basic human emotions as happiness, sadness, disgust, anger, fear, and surprise in his research in 1972[1,2]. His study uses human facial expressions and external features as core materials of analysis. The result of his human emotional analysis is divided into categorized numbers and diversified of characteristic emotions, however Ekman advised Pixar animation developer to characterize main five emotional characters since there

1) Inside Out Trivia. IMDb  
<http://www.imdb.com/title/tt2096673/trivia>

2) Paul Ekman is an American psychologist who is a pioneer in the study of emotions and their relation to facial expression.

is no shortage in defining the development the five emotional characters in the animation "Inside Out"[3].

The following [Fig. 2] is a picture of six basic human emotions originally studied by Paul Ekman.



[Fig. 2] Paul Ekman's six basic emotion

### 2.2 Emotional setting criteria in "Inside Out"

The dictionary meaning of character in animation is the character who uses living personality or characteristic, the protagonists who uses animals and plants to leads the story through their thoughts and expressions of emotion[4]. Although the characters for conveying the theme are generally set in a complex manner, the five characters in the "Inside Out" have a sense of empathy because they have the premise by expressing the five roles of human emotions.



[Fig. 3] 3D animation "Inside Out"

In this way, this study indicates the five different characters based on the five emotions, then analyze how individual character's emotional tendency is

effectively expressed through visual elements in the facial expression and color expression.

### 3. Analysis on emotional characters

This study is based on emotional character's outward appearance from the body shape and theme color to define the characteristic differences of the emotional outlines in the animation. In the study's research, the table of analysis arranges a general reference point of the five character models to extract methodology in facial expression and color expression.






First, the proportion of five characters are analyzed in advance to compare the emotional appearance, result came out five characters' head size is between 1/2 to 1/3 out of their whole body scale. The term of proportion means a relative size of the relationship with the whole, part of object[5]. The purpose of this study used each characters' proportion to specify the reason of selecting the facial expression since the visual part of head and body are equally scaled.

Next, the external theme color of five characters are analyzed to compare the emotional appearance, result came out five characters' skin color and tone of costume are composited in both analogous color schemes and complementary color schemes. This study analyzes characters' intentional color scheme effect through the emotional process of psychological changes using color values.

The following <Table 1> is a brief summary of characters' comparison analysis of name, gender, emotion, body, facial, and cloth for this study. Character Joy has a color of soft and warm yellow tone with proportion ratio of 3.4. Next character Sadness has a color of cold blue tone with proportion ratio of 1.85 which makes more unsafe form than others. Character Disgust and Fear look anxious with color of green and purple tones, and the body shape has an proportion ratio of 2.6 to 2.5. Last character Anger has an intense

red color scheme with proportion ratio of 1.9, and this is an unstable shape like Character Sadness.

<Table 1> Five emotional characters from Inside out

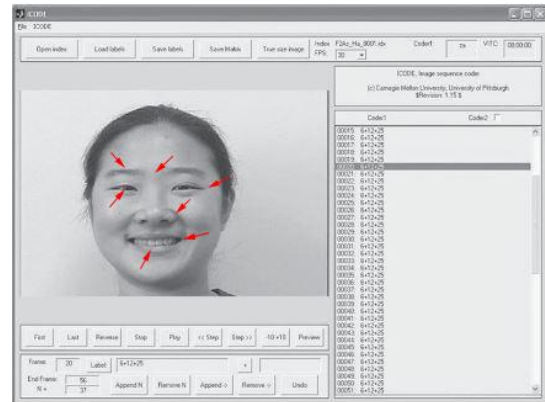
	Name	Joy		
	Gender	Female	Ratio	3.4
	Emotion	A source of great happiness		
	Body	Orange	Slim and stretched out	
	Facial	Short blue hair, no nostril		
	Cloth	Light yellow lime dress		
	Name	Sadness		
	Gender	Female	Ratio	1.85
	Emotion	Associated with unhappiness		
	Body	Blue	Round and stout	
	Facial	Medium blue hair, no nostril		
	Cloth	Light blue knitted sweater		
	Name	Disgust		
	Gender	Female	Ratio	2.6
	Emotion	A strong feeling of dislike		
	Body	Green	Slim and curvy	
	Facial	Medium green hair, no nostril		
	Cloth	Green flared dress		
	Name	Anger		
	Gender	Male	Ratio	1.9
	Emotion	A feeling of upset of accident		
	Body	Red	Flat and short	
	Facial	No hair, no nostril, brick teeth		
	Cloth	White shirt and brownish pants		
	Name	Fear		
	Gender	Male	Ratio	2.5
	Emotion	An unpleasant feeling of danger		
	Body	Purple	Long thin and stick	
	Facial	Single purple hair, no nostril		
	Cloth	Blueish check knit vest and pant		

### 3.1 Analysis on facial expression

This study has reason to analysis the feature of facial expression of five characters since the scale of their faces are occupied in large percentage comparing to the body proportion. In addition, Paul Ekman, who is the psychologist and development consultation in the animation "Inside Out", had developed his research in emotion expression system which is called Facial Action Coding System (FACS)<sup>3)</sup>. This coding system

is based on the changes of facial muscle shape and wrinkles, simplified part of the change information can be synthesized on the system to combine the human emotion.

The following [Fig. 4] is an example of image analyzed by Paul Ekman and Friesen's FACS, and it indicates emotional changing points with arrows.



[Fig. 4] Paul Ekman's FACS

When classifying human emotion of happiness with FACS, the edges of the eyes are wrinkled, the clown is raised, and both ends of the mouth are raised. In the case of a sadness with FACS, the upper eyelid is sagged and the focus of the eyes are blurred while the ends of the lips are lowered. In the case of a disgust with FACS, the nose creates wrinkles while upper lip moves up. In the case of an anger with FACS, the gap between the eyes is narrowed and sharpened while the lip is thinned. Finally in the case of a fear with FACS, the mouth becomes narrowed, the eyebrow and upper eyelid rise while the mouth opens with ends increases slightly toward the cheek.

Next, this study converts five characters' facial expression into the psychological expression values in the screening time of entire animation based on the impressions and psychological relationships examined

3) FACS is a system to taxonomize human facial movements by their appearance on the face, based on a system adopted, and published in 1978 by Paul Ekman and Friesen, and Joseph C.

Ekman's earlier research. Thus this record has numerical values of the five designated expressions arranged in repetitions, and the facial expression corresponds to each character's name to digitize for analyzing the emotional identification.

In the case of character Joy, it shows 151 times of happy expression among all the animation sequence, and this is more than three times as many as Joy's other facial expressions. On the other hands, the change of its expressions of sadness, disgust, and fear can be predicted as a result of character's correspondence with the expression of various progress of the story. For reference, Joy's anger expression, which is the object of the opposite, is numbered 28 times which makes the purpose of conveying pleasure in character name is confirmed.

In the case of character Sadness, it shows 59 times sad expression among all the animation sequence, but this is not outstanding numbers compared to other expressions of character Sadness since sad emotion is included to the facial expression in entire animation story. In addition to the number counting method in this study can be interpreted as a result consistent with personality of the character, while the other expressions can be understood as being recorded low.










In the case of character Disgust, maximum number of 49 times of negative expression among all the animation sequence, since the frequency of character Disgust is relatively lower compared to the maximum number of character Joy. It's second most pleasant expression number was 25 times, and this can be interpreted in the Pixar animation's bright atmosphere targeting audiences for all ages.

In the case of character Anger, it shows 31 times of anger expression among all the animation sequence, and this is smaller number compared to 37 times of happy expression. However, unlike character Joy's pleasant laugh, character Anger expresses explosive anger with malicious pleasure to express anger. It can be understood as the character Anger is also lack of

emotional control during intensive facial expression changes compared to other facial expressions.

Finally, in the case of character Fear, it shows 64 times of fear expression among all the animation sequence, this is a more expressive facial expression than the other facial expression while expression matches the character set. Character Fear's happy expression shows in 42 times, and this result can be interpreted in the sense of conveying the joyful genre in the animation as well as character Disgust.

<Table 2> Facial expression for five characters

	Joy	Sadness	Disgust	Anger	Fear
#	151	32	25	37	42
Happy					
#	55	59	5	5	7
Sad					
#	51	9	49	11	13
Disgust					
#	28	2	4	31	8
Angry					
#	50	39	23	15	64
Fear					

As described above, the facial expressions of the characters show emotional differences in the total number of repetitive counts, thus it can be also confirmed through the numerical investigation of characteristics based on the emotional changes per character. For the reference, this study reveals excluding the expressionless facial emotions from the analysis to reduce the statistical error range.

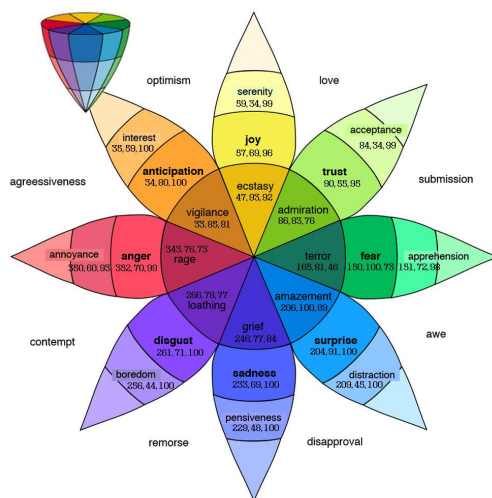
### 3.2 Analysis on color expression

Following by the facial analysis, proceeding to the color analysis of the five psychological characters are



based on a preliminary study by psychologist Robert Plutchik's Wheel of emotions<sup>4)</sup>. He classified colors are closely related to psychological expression as defining emotional changes to represent emotion with hue, saturation, and brightness[6].

The following [Fig. 5] is an image explaining the Wheel of emotions. Each of 32 colors represents human emotions. Higher the saturation means stronger the emotional intensity, and brighter the color means blurrier the emotional identity.



[Fig. 5] Plutchik's Wheel of emotions

In this study, five characters are converted into a pixel unit images, and those pixels are classified into the group values of hue, saturation, and brightness to derive color analysis correlation.

In order to simplify the rendered image of five characters with various colors, the study reconstructs developer Pixar's original "Inside Out" images into the group combination of pixels using the Photoshop program's Pixelate effect. In the pixelization process, the analysis was based on the one frame considering the relative size of each five character, that is total sum of 600 pixels composed by 20 pixels in width and 30

pixels in height. Finally, the result groups of primary and secondary color are applied to the Wheel of Emotions to categories the characters' personality using the hue, saturation, and brightness values.

The following <Table 3> is an analysis summary of five emotional characters' color expression based on the theory of Wheel of emotions.

Character Joy uses 163 pixels (27.2%) out of 600 pixels in the frame. The result of primary color confirms the average hue and saturation of yellow series and high brightness values (H:58, S:45, B:94) which belongs to emotion joy. In addition, clear color contrast on its hair belongs to the blue series (H:208, S:65, B:77) on average color scheme. This analysis shows consistent result with repetitive surprise of character Joy as it represents feeling of pleasure.

Character Sadness uses 202 pixels (33.7%) out of 600 pixels in the frame. The result of primary color confirms the medium hue and saturation of deep blue series and medium brightness value (H:231, S:70, B:54) which belongs to emotion sad. In addition, similar bright blue tone of its costume belongs to the saturated blue series (H:204, S:43, B:75) on its color scheme as a secondary color. This analysis shows results that correspond to expressing the emotion of sad and surprise which the main emotions of character Sadness in animation.

Character Disgust uses 128 pixels (21.3%) out of 600 pixels in the frame. The result of primary color confirms that average skin color of medium green series (H:204, S:43, B:75) unexpectedly shows feeling of emotion fear. However, the scarf's purple series (H:268, S:7, B:78) expressed the negative or disgust as character's main emotion.

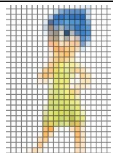

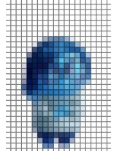

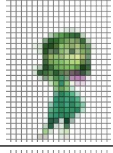

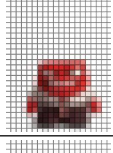

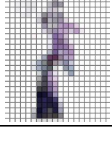

Character Anger uses 137 pixels (22.8%) out of 600 pixels in the frame. The result of primary color confirms that average skin color of medium red series (H:359, S:43, B:75) shows the feeling of angry corresponding to character role. The dark red series (H:354, S:37, B:44) on his costume, as secondary color,

4) Plutchik's wheel of emotions is an infograph that uses the color wheel to illustrate variations in human affect and the relationship among human emotions.

also shows low saturation and brightness to express the rage which assist character's emotion.

Finally, character Fear uses 105 pixels (17.5%) out of 600 pixels in the frame. The result of primary skin color of medium purple series (H:279, S:25, B:64) shows emotion disgust. However, the costume's blue series (H:215, S:16, B:75) expressed in the result of emotion surprise. The tendency disgust and surprise are understood as interpretation of emotion fear.

<Table 3> Color expression for five characters

Character	Range	Primary H,S,B		Secondary H,S,B	
		P	58,45,94	S	208,65,77
		P	Joy	S	Surprise
		P	231,70,54	S	204,43,75
		P	Sad	S	Surprise
		P	104,26,70	S	268,7,78
		P	Fear	S	Disgust
		P	359,43,75	S	354,37,44
		P	Angry	S	Rage
		P	279,25,64	S	215,16,75
		P	Disgust	S	Surprise

In this way, the way of setting the five characters' emotion through analysis of color expression is clearly matched to the Robert Plutchik's Wheel of Emotion in general concept of character roles. Therefore it can be inferred as a clear reference point for color expression to represent emotional appearance during the character development.

#### 4. Conclusion

In conclusion, two main emotional characters of Joy and Sadness are matching the visual target of both facial expression and color expression as the result of emotional appearance in distinction. Another emotional characters, Disgust and Fear, are matching the visual target of facial expression, but their color expressions are matching secondary color rather than primary color in emotional appearance in distinction. For the last emotional character Anger shows his angry expression followed by malicious laugh in the facial expression, However its color expression of angry and rage present character's tendency of emotional appearance in distinction. As a result of comprehensive analysis, five emotional characters satisfied the tendency of human basic emotions to express visual target appearance in psychological perspective.

This study finds these core emotion features are necessary to define in terms of both character developers and storyboard designers in modern animation industry. Furthermore, analysis based on these psychological emotional elements will contribute to character development research into various cultural industries such as game and advertisement industries. In addition, statistical immersion studies for emotional character development can be derived through analyzing various audience in different ages.

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