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Descriptive Analysis of Human Emotions Based on Eye Pupils

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ABSTRACT:

Facial emotional expressions are viewed as the most descriptive way to understand the human's state of temperament during confronting communication. In this work, numerous statistical approaches have been applied to human eye pupils with static images of the Chicago face dataset (C.F.D.) to analyze and classify the categories for emotions: Happy, Fear, Anger, and Neutral. This study aims to develop the specific architecture for the image processing domain after applying different enhancement techniques to the human eye pupil for analysis & recognition of facial expressions. This work is divided into three phases. In the first phase, data preprocessing is performed to prepare according to the work requirement. The colour images are converted into negative by applying the pixel intensity controlled mechanism. The second phase defines the boundary to compute the feature using the Circular Hough Transform algorithm. Lastly, statistical approaches are applied to extracted features to corporate the central point of the pupil. This corporation of the main point presents the effects of emotions. While comparing people of different Age groups, it is concluded that pupils constricted on Anger to varying levels in other age groups. Suppose further it is discussed about the cross-cultural and gender-wise comparison. In that case, Happy Emotion affects most and results towards dilated pupils like Anger emotion affects most on, constricting the pupil size.

KEYWORDS: Emotions Analysis, Pupil size, Cross-cultural Differences, Gender-based Analysis, Age-based Analysis

1. INTRODUCTION

Human emotion is one of the critical aspects of daily life and essential for significant social interaction. The different systems of emotion recognition must provide good recognition performance, case in point, to avoid misunderstanding the mental state of any person. Human eyes communicate many more than we realize. Human eyes play an essential role in non-verbal communication. It may be consciously or not that how we look at someone, move our eyes, or make eye contact with someone can say much about what we are feeling and thinking. The Human Eye structure is shown in Figure 1.

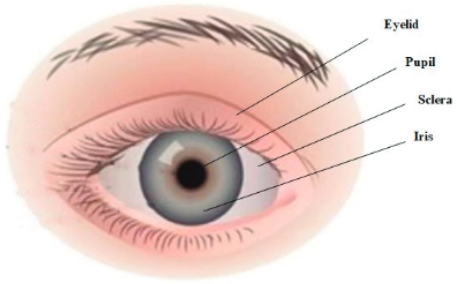


Figure 1: Human Eye structure

Facial expressions, body language, or an amalgamation of all these modalities. To be capable of recognizing human emotions

is the foundation for human sympathy; while interacting with other people, human beings depend on their abilities to interpret and perceive emotions in further people and adjust their responses automatically according to perceived emotional states. Furthermore, existing literature validates that recognition from facial expressions can yield higher recognition levels. [1] described the methods based on waves and non-electrical parameters for measuring emotions. There are numerous endeavours at tending to automatic emotion recognition as of the outward appearance of expressions by using Deep Learning and other new ML methods. Therefore, many advanced recognition standards have been fixed on datasets containing static face expression images gathered in controlled environments.

This work aims to develop the specific architecture for image processing after applying different enhancement techniques to facial images to analyze facial expressions in an unimpeded environment. The categories considered for emotion analysis are Happy, Fear, Anger, and Neutral. Latterly these emotions are considered widespread emotions across all cultures. The uniqueness of this research is the detection of pupils, especially for the objective of emotion analysis. As the problem statement defines, "Is it possible to analyze the human emotions after applying various mathematical approaches to the human eye pupil with static emotional images?" The rest of the article is structured as follows: Section 2 presents the work's Literature, Section 3 presents the methodology, Section 4 presents the results and discussions, and Section 5 analyses the work's conclusion.

2. RELATED WORKS

There is a significant role behind emotional understanding in developing Human-Computer Interaction systems. Identification of human emotions supports computer systems for the formulation of proper responses. Emotional expressions have a long-lasting history. It has been a deep-rooted area of research for over a century. Recognition of emotions is one of the most active research topics currently and is also an increasingly great challenge and strong interest [2]. It initiated more acceptance that reactions to emotions can be nominated as a dominant feature in sensible human behaviour. Results of experiments based on subjects from a renowned dataset, "Chicago Face Dataset (C.F.D.)" [3], determine that the proposed techniques can efficiently be used to assess the analysis of facial emotions. Furthermore, images of Black people are also used from C.F.D. to prove the proposed system's strength to check the algorithm's stability. Finally, the results are impressive, especially when tested after converting the image into negative. Some of the sample images from C.F.D. are shown in Figure 2.

Communities of IEEE & U.S. National Foundation of science [4-5] have paid for many workshops and conferences related to this research area. These days there is a trend to substitute traditional techniques of image representation with well-organized Algorithms for semi-supervised or unsupervised feature learning & hierarchy-based feature extraction. On the other hand, Deep Learning (DL) comprises many known Architectures & outcomes, it is significant to determine the nature of

Figure 2: Sample image galleries from C.F.D. [3]

problems related to Machine- Learning before it's functional. Tomkins [6] suggested nine primary emotions (interest, Anger, disgust, distress, contempt, joy, fear, surprise, and shame). In contrast, eight basic emotions (Anger, acceptance, hate, anticipation, joy, trepidation, wonder, and sadness) belong to plutchik's emotion wheel [7-8-30].

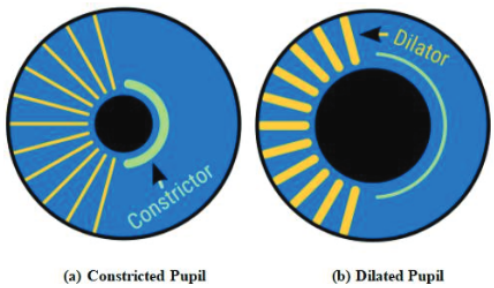


Figure 3: (a) Constriction (b) Dilation structure of eye pupil [9].

Figure 3 shows pupil constriction and dilation, which occurs while the iris sphincter muscle contracts and squeezes the iris's inner side. When the iris dilator muscles contract then, it pulls the inner side of the iris outer, thus it causes dilated pupils [9]. For effective algorithm development of facial expression recognition, many well-known databases of enough size are requisite. The selection of datasets in this type of study is one of the most critical aspects. Most of the databases are created after the requesting Participants display several emotional expressions. So, the characteristic which differentiating different databases is expressions performed spontaneously or intentionally. For example, CK+ [10] and A.D.F.E.S. [11] both databases were shaped based on deliberate expressions, whereas D.I.S.F.A. [12-31] was created by using unprompted expressions. Accordingly, well-built datasets are prominent due to their ability to include as many aspects as possible. Another critical characteristic is image resolution.

Depending upon the utilized techniques, especially regarding feature extractions, the image can stand effective in high resolution; this could be advantageous for the computational rate of the system. High-resolution images are required in this work for preprocessing and to find better results so that Chicago faces the dataset It consists of 158 high-resolution images and uniform

images of White and Black females and males between 18 to 40 years old. The Chicago Face dataset is preferred over other datasets because others have fewer resolution images and lack information about a target. Table 1 describes the maximum number of available data sets from which emotion analysis can be possible. Eye-Tracking is said to be the method of identification of the gaze point or the spot where users are watching for a specific visual stimulus. Different scholars use different devices for Eye-tracking, like Virtual Reality [16, 17, 28], Mobile Eye-tracking [14-15], and Desktop Eye-tracking [13-32]

Table 1: Publicly available databases of face expressions

Databases	Imaging	Camera view	Images Resolution	No of Subjects	Type
Chicago Face Database as (CFD) [3]	Static	Frontal	2444 * 1718	158	Spontaneous
Belfast Naturalistic [24]	Video Frames	Frontal	Mixed	125	Spontaneous
Cohn-Kanade CK+ [10]	Video Frames	Frontal	640 * 490	123	Posed & Spontaneous
MMI [25]	Static	Frontal and 90°	720 * 576	101	Posed & Spontaneous
DISFA [12]	Video Frames	Frontal	1024*768	27	Spontaneous
ADFES [11]	Static	Frontal	720 * 576	22	Posed
JAFFE [26]	Static	Frontal	256 * 256	10	Posed

3. METHODOLOGY

The methodology incorporates the portrayal of the phases followed systematically to create an Emotion Analysis System, which analyzes by Eye Pupil. For analysis of facial expression through static images, an algorithm is required, specially designed for pupil detection and radius measurement of eye pupils at different emotional stages. The approaches used for Eye feature detection are based on up-to-date literature reports. Consequently, in this research implemented.

The technique for Pupil detection is the Circular Hough transform used by [27-29], in which

Code for radius measurement is implemented. This influential descriptor is applied to the human eye pupil to get relevant information like pupil radius for each image of emotions like Fear, Anger, Neutral and Happy. So, the feature data is fed into a simple Excel sheet in a Specific format after extraction of the data. Further analysis is done through different techniques of statistical tests or other graphical representations for comparing all emotions with each other so that the difference between each emotion can be visible. Figure 4 shows the complete framework of this work.

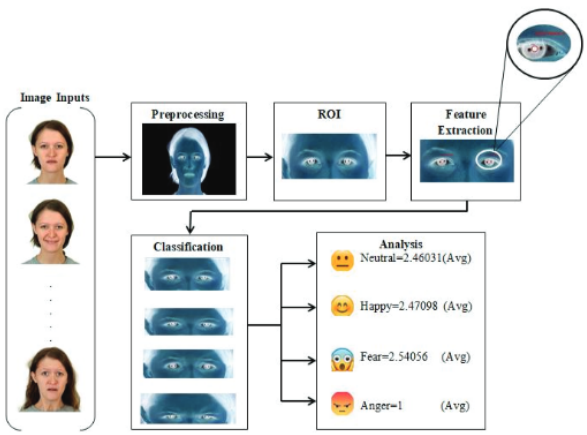


Figure 4: Representation of the proposed framework

3.1 Data Acquisition and Preparation

Acquisition of data is the way to test sampling signals that measures natural physical conditions & conversion of subsequent samples into alphanumeric values that the computer can easily influence. Analog data is acquired from images for further. Gathered data can be used for the improvement of efficiency and to ensure the reliability of Emotion recognition

Through different ways Chicago Face Dataset (C.F.D) consists of 158 highly-resolution and standardized images of White and Black females and males between the ages of 18 to 40 years expressing emotions (Happy, Neutral, Anger and Fearful). All the data is prepared, conferring upon the needs and different modifications are done to the original data set. Figure 5 expresses the refined data set.

3.2 Data Preprocessing

Data preprocessing means the transformation of raw data into meaningful or understandable information. For significant results, images of the modified dataset are converted from RGB

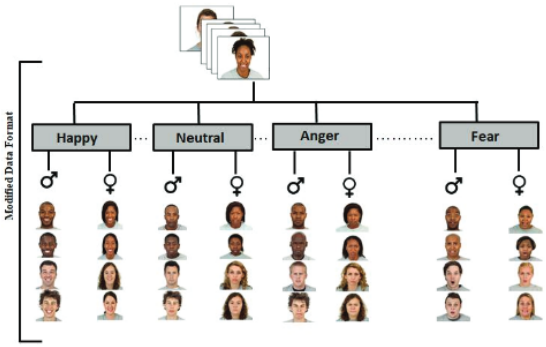


Figure 5: Refined dataset

to Negative. So, the detection of both eye pupils can be made accessible. For conversion, a python code converts the image individually into the negative, as shown in Figure 6. A library of Python named "P.I.L." is used for that purpose in Python. Image is Loaded through the following P.I.L. command "im = Image. open (or Path of image')". Secondly, the point function is applied for pixels manipulation through the following command in Python of P.I.L. library "result = im. point (lambda p: 255 -p)" for getting a negative image and for black people, 80 is given as pixel value instead of 255 just because of the image clarity. At the same time, lambda is an expression or function that can take any number of arguments but can only have 1 expression.

Figure 6: Images preprocessing.

3.3 Region of Interest

Region of interest (R.O.I.) is a part of any image you need to operate or filter. All the images are cropped so that the interested regions can be more visible and further work can be more accessible. To crop the acquired image, the function [18] is used to compute the rectangle area. Such as, rectangular values are 800 from the Left, 800 from the Right, 250 from Top and 650 pixels from the bottom. Figure 7.
shows the criteria for crop handles which remains the same for all images. Following Eqs 1 represents a simple image: Then R.O.I., as per the Matlab built-in function, is extracted according to Eqs (2) & (3).

$$F(x,y) \equiv \begin{matrix} f(0,0) & f(0,1) & f(0,2) & ! & f(0,N-1) \\ f(1,0) & f(1,1) & f(1,2) & ! & f(1,N-1) \\ f(2,0) & f(2,1) & f(2,2) & ! & f(2,N-1) \\ " & " & " & " & " \\ f(M-1,0) & f(M-1,1) & f(M-1,2) & ! & f(M-1,N-1) \end{matrix} \quad (1)$$

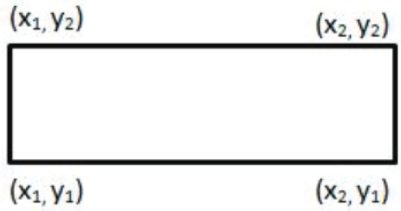


Figure 7: Representing R.O.I. of the eye region

Where

$$= \quad , \; ; = \\ , [\; !"\# \; !"\# \qquad h \qquad h \;] \; ; \quad (2)$$

$$!"\# = (\; !, \; !) \quad (3)$$
$$!"\# = (\; !, \; !)$$
$$h = (\; ! - !)$$
$$h \; = (\; ! - !)$$

3.4 Feature Extraction

Figure 8 represents the extracted features used to detect pupil radius area so that the analysis can be done. For that purpose, function in [19] is used. It has two steps. The first step is accepting the preprocessed images for eye pupil detection. The second step is to design a pupil circle and define the pupil's center area, which is used for measuring the radius.

Let(h,) be the centers of the circles with radii r

$$!! = (\; -h)! + (\; - \;)! \quad (4)$$

Eq.4 and Figure 8 represent the Hough circle
(2) Whereas value "h" is the center point x coordinate and value "k" is the center point

(3) y coordinate.

Where

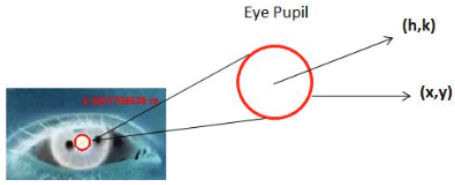


Figure 8: Representation of the center point and boundary of the pupil

Algorithm: Feature Extraction

1. Input: A raw images dataset
2. Output: A dataset with synchronized features
3. Algorithm:
4. Declared variables image, negative_img, roi, centers, radii, metric
5. Take an Image from a dataset
6. Convert the corresponding image into negative_img (Fig. 6)
7. Crop R.O.I. (Region of Interest) from the entire negative_img (Fig. 7).
8.Set the range of circle Min-Max(6-15) and Get centers, radii, metric
9. Focus on both pupils and mention the size of an image
10. for k =1 to size(radii). Do
11. Size-of-pupil = sprintf('%2.10f m', radii(k)*0.264583333);
12. Compute pupil radius (Eqs. 4)
13. text (centers (k,1), centers(k,2)-50, size-of-pupil, 'Color', 'r', 'FontWeight', 'bold');
14. End

4. RESULTS AND DISCUSSIONS

Figure 9 illustrates the process of Average through which the results are extracted, whereas P.L. stands for Left Pupil and P.R. stands for Right Pupil. These acquired results after average are the representative of Left and right pupils. Although some images of anger emotion in the dataset have closed eyes, it is impossible to measure the pupil size because of the closure of Eyelids, so the average default value for that type of image is taken as 1 for smooth results. Average values are extracted from obtained results after applying Eqs.5.

$$!"\# = \frac{!_! + !_!}{!} \quad (5)$$

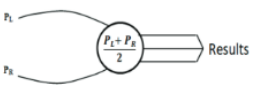


Figure 9: Extracting Average results

4.1 Descriptive Statistics of Pupil Sizes between Genders

All the data of males and females are separated to examine the variations between the two sexes. According to Figure 10, it is represented that the females in graph (b) show more prominent pupils in all emotions despite anger emotion. In this case, a female has an average pupil size of 1.81369 mm, whereas a male has 2.09650 mm. Only in anger emotion pupil size of a female is less dilated than a male. Results are represented in Fig 10 (a) and (b).

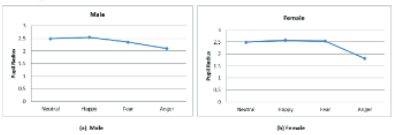


Figure 10: Pupil Size differences among two sexes (a) Male (b) Female

Descriptive analysis is performed on the dataset of 28 females and 19 males having

Different age slaps. Females show comparatively stronger emotional fluency, whereas males have sturdier emotional involvements with angry & positive stimuli [21]. So the gender-based results prove Gross & Levinson's [21] work. [20] proves the statement that minor but substantial gender variances in emotional expressions have been reported for grownups, with females showing larger emotional fluency, mainly for positive emotions & assuming negative emotions like fear & sadness. An Autonomous pairwise assessment has shown that females delivered a score of fixation duration meaningfully more significant than the score provided by unpleasant male emotions like Anger or Fear images [22]. High Standard deviation values of females indicate that the variation among female Eye pupils is slightly higher than the male Eye pupils. A detailed comparison is shown below in Tables 2 to 5.

Table 2: Neutral Emotion

	Male	Female
Mean	2.489129	2.499918
Standard Deviation	0.262009	0.290367
Sample Variance	0.068648	0.084313
Minimum	1.84275	1.924295
Maximum	2.94249	3.300355
Count	19	28

Table 3: Happy Emotion

	Male	Female
Mean	2.541837	2.577336
Standard Deviation	0.223419	0.250817
Sample Variance	0.049916	0.062909
Minimum	2.14656	2.02378
Maximum	2.875235	3.1736
Count	19	28

Table 4: Fear Emotion.

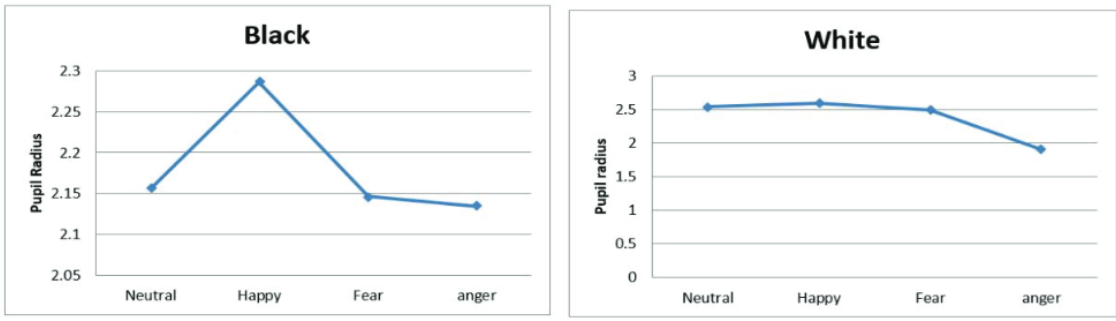
	Male	Female
Mean	2.353158	2.533291
Standard Deviation	0.274112	0.29771
Sample Variance	0.075138	0.088631
Minimum	2.00798	1.97463
Maximum	2.99411	3.0975
Count	19	28

Table 5: Anger Emotion

	Male	Female
Mean	2.096506	1.813691
Standard Deviation	0.787249	0.815583
Sample Variance	0.619761	0.665176
Minimum	1	1
Maximum	2.989105	2.9938
Count	19	28

4.2 Descriptive Statistics of Pupil Sizes among Cross-cultural differences

If we talk about people of different regions, like black and white people,, we can say that black people have less pupil dilation than white people. An analysis is done on 5 black and 42 white people's images. Figure 11 graphs (a) & (b) represent the detailed analysis in which neutral point. Black shows smaller pupil size compared to white people, and black shows massive dilation while changing their emotion from neutral to Happy compared to others. White people didn't claim much difference from all other emotions. The main thing is that both claim low pupil dilation in anger situations which is unique in both.



(a) Black (b) White

Figure 11: Pupil size differences among cross-cultural peoples (a) Black (b) White

A descriptive analysis of all four emotions is shown below in four Tables 6 to 9 separately, through which we can do the Detailed analysis and essential details about the differences between cross-cultural peoples, e.g. (Black & White). The neutral emotion S.T.D. value is 0.25812, which is more significant than the Neutral black value of 0.18523. Same that Happy white =

0.223288 > Happy Black = 0.186488, Fear white = 0.286951 > Fear Black = 0.214916 and Anger white = 0.846877 > Anger Black = 0.306873. These differences in standard deviation show that the pupil variation rate among white people is much higher than among black people.

Table 6: Neutral Emotion

	Male	Female
Mean	2.535961	2.156159
Standard Deviation	0.25812	0.185237
Sample Variance	0.066626	0.034313
Minimum	1.84275	1.924295
Maximum	3.300355	2.376345
Count	42	5

Table 7: Happy Emotion

	Male	Female
Mean	2.595912	2.286402
Standard Deviation	0.223288	0.186488
Sample Variance	0.049858	0.034778
Minimum	2.14656	2.02378
Maximum	3.1736	2.51762
Count	42	5

Table 8: Fear Emotion

	Male	Female
Mean	2.497865	2.146358
Standard Deviation	0.286951	0.214916
Sample Variance	0.082341	0.046189
Minimum	2.00798	1.97463
Maximum	3.0975	2.43382
Count	42	5

Table 9: Anger Emotion

	Male	Female
Mean	1.903422	2.134651
Standard Deviation	0.846877	0.306873
Sample Variance	0.717201	0.094171
Minimum	1	1.8436
Maximum	2.9938	2.54537
Count	42	5

4.3 Age Group-wise comparison of emotions

The main effects of emotions were perceived by (Persons including males & females = 47, Mean age = 26.50), and data is divided into four age groups with a difference of 5 years relatively to measure Variations accurately without facing any issues. Line graphs are shown below in Figure 12 according to groups 17-21, 22-26, 37-31, and 32-37. The size of Pupils and emotional perceptions are entangled with each other, but their association is developed over age [23].

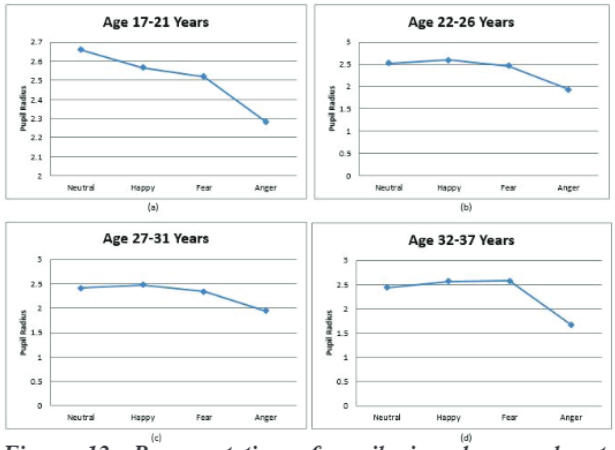


Figure 12: Representation of pupil size changes due to emotions according to Age (a) Age 17-21 (b) Age 22-26 (c) Age 27-31 (d) Age 32-37

Diminishing pupil size improves the assessment rate of valence and emotional intensity for Anger but not happy, fearful, or neutral expressions of the face. Connotation between small or large pupils and negative and positive impressions develops in overage and is absent in youngsters. A person lying under the age of 17-21 has a larger pupil size at neutral, decreasing while it changes in Happy and Fear and Anger. Persons lying under the age 22-26 have a larger pupil at happy emotion because they claim a 2.594782 mm pupil radius, which is more significant than all other emotions average between same-age emotions, if we talk about the persons lying under 27-30, they also show larger pupil size on happy emotions and claim a 2.47633 mm pupil radius. Persons aged 31-37 declared most dilated pupils on Fear emotion, which is 2.571194 mm and more significant than other emotions' average values. The average pupil size concerning age is represented in Table 10 below.

Table 10: Average pupil size according to age

	17-21	22-26	27-31	32-37
Neutral	2.66050	2.52057	2.40750	2.43415
Happy	2.56535	2.59478	2.47633	2.56732
Fear	2.51943	2.46890	2.33745	2.57119
Anger	2.28200	1.9360	1.94713	1.66869

5. CONCLUSIONS

This study aimed to develop the specific architecture for the image processing Domain after applying different enhancement techniques to human eye pupils to analyze facial expressions. Three different algorithms were combined for emotion analysis purposes and achieved good analysis results on the Chicago face database. Furthermore, an algorithm that describes the Eye's

Image luminance at different values according to the clarity of an image for white and black people is presented. As a texture analysis approach, the RGB image is converted into a negative image. Initially, descriptive analysis is performed on two different sexes, which shows that in both sexes' happy emotion affects more than others and pupil dilation Takes place more than other emotions. Female pupils dilated more than males in Fear emotion. In cross-cultural differences, the experiment concludes that black people's pupil dilation is more than white on happy emotions, whereas their variation rate is low compared to white people. According to the Age differences, it is concluded that the peoples who comprise between the age of 17- 21 at a neutral point claim large pupil size compared to other age groups, and the persons lie between 32-37 claim high pupil size in fear emotion. In general, based on the results, we can say that happiness affects more on pupil size & tends towards more dilated pupils. In the anger emotion, the pupil size is constrained compared to other emotions.

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