International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

Facial Emotion Recognition using Quantification Analysis

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Abstract –*With modern world crippled by civil wars ongoing for years now in Yemen[1] leading to psychological sufferings; increasing number of child maltreatment leading to depression and other psychosocial impacts[2]; Parkinson's Disease (PD) and Huntington's Disease (HD), human civilization is in dire need of finding solution to end this. In this time of distress, "Facial Emotion Recognition" would be the answer to all of these problems. Civil wars, maltreatment and human abuse lives deep scar on our brain. People who have faced this may show different facial emotions than normal, healthy human beings. Patients who are diagnosed with PD or HD will show facial maskings [3] or rigid facial expressions. Using this concept, FER would be a useful technology in identifying human who have experienced abuses or have been diagnosed with PD or HD at an early stage. Hence we can act quickly, eventually saving lives of people. Here in this research we have built a python algorithm titled "BHAVAH GRI 1427" (renamed herein Bhavah) based on "Quantification of Human Emotions" to identify the human emotions. In the this methodology, we have quantify human emotions based on several quantification parameters like RGB, Fast Fourier Transform etc. Based on this, a detailed manual analysis has been done and eventually classified onto six basic human emotions.*

Key Words: Bhavah, Facial Emotion Recognition, Parkinson's disease, Huntington's disease, Quantification

1. INTRODUCTION

With the growing number of cases of child maltreatment, domestic violence, civil wars, diseases like PD and HD, worldwide, it has become important that researchers and doctors can identify this people and ultimately helping in saving their lives. Human who have been experiencing at least one of the above, have one thing in common. They show rigid facial expressions relative to that of human leading a healthy and normal life. Hence the authors of these papers have decided to work on Emotion recognition. This research focuses on "Quantification of Emotions" to analyze and classify various emotions of human. Hence this algorithm works for quantifying the images and in turn helping researchers to classify emotions. According to Sanskrit, "Bhavah" means "Emotion". The development of the algorithm has been completed in the year of 1427 (Bengali Calendar) or May, 2020, during summer season in India. In Bengali, summer is known as "Grishokal". Hence, it is decided to take the first three letters i.e. "GRI" and the year in which the algorithm has been developed. This way algorithm got the name "BHAVAH GRI 1427".Bhavah has been developed in Python environment. At first, we take the emotion of human as input. After this we quantify the image taken by finding values of parameters: RGB value of emotions, mean value, standard deviation, histogram, Fast Fourier Transform and Magnitude Spectrum. Then manual, detailed and comparative analysis has been done. It has been found after performing the manual analysis that the six basic human emotions – sad, anger, disgust, surprise, happy and fear, show unique pattern in the position of histogram peaks, specific range of value in standard deviation and mean unique shape of central dark spot in FFT, which varies from emotion to emotion. This observation has been finally noted down to observation table which will help the researchers classify the images into various categories of human emotions. We have successfully defended this methodology by applying the same algorithm on a larger datasets of emotions and checked its continuity.

1.1 Motivation

Studies show that as of November 2018, 6,872 civilian has been killed and 10,768 wounded in civil wars in Yemen alone [4]. It has also been seen in researches conducted in between 2000-2008, that most child abuse goes unreported and the trauma leads forever [5].U.N. has found that more than 30,000 deaths a year worldwide takes place due to domestic abuse [6]. It has been found in researches that women victims of domestic violence show significant cognitive changes and emotional numbling [7].With more than 10 million people worldwide live with Parkinson's disease, and nearly one million people in the United States will be afflicted with the condition by 2020[8], which is more than the combined number of people diagnosed with multiple sclerosis, muscular dystrophy, and Lou Gehrig's disease. This insane and painful event has motivated us to build Bhavah which would help the researchers to identify human, child who have faced abuses in life or have PD or HD.

1.2 Background

In past research works have been done on identification of facial emotions of human using feature extraction and classification algorithms [9, 10]. Cross modal methodology has also been used to detect emotion in speeches [11].

2. MATERIALS AND METHOD

Bhavah has been developed in python environment and can be broadly divided into multiple sections: Main Input Section, Conversion to gray scale image, Measurement of height and width and Quantification of image. Bhavah uses various python libraries: numpy, cv2, matplotlib and matplotlib.pyplot. It uses numpy for working with Fourier transforms, standard deviation and magnitude spectrum. Bhavah also uses matplotlib and matlpotlib.pyplot for plotting of histograms of inserted images. Moreover cv2 has been used to develop the algorithm in OpenCV.

2.1 Fundamental Emotions in Human

According to the book "Discovering Psychology" by Don Hockenbury and Sandra E. Hockenbury, an emotion is a complex psychological state that involves three distinct components: a subjective experience, a physiological response and a behavioral or expressive response"[12]. We have used the following six emotions of human beings in the research work.

2.1.1 Sadness

Sadness is an emotional pain associated with, or characterized by, feelings of disadvantage, loss, despair, grief, helplessness, disappointment and sorrow [13]. An individual experiencing sadness may become quiet or lethargic, and withdraw themselves from others.

2.1.2 Surprise

Surprise is defined as to cause of someone to feel in amazing feelings [13].

2.1.3 Anger

Anger can occur when a person feels their personal boundaries are being or going to be violated [13].

2.1.4 Disgust

Disgust is a feeling of dislike. Human may feel disgust from any taste, smell, sound or tough [13].

2.1.5 Fear

A distressing emotion aroused by impending danger, evil, pain etc., whether the threat is real or imagined [14].

2.1.6 Happy

The emotion evoked by well-being, success, or good fortune or by the prospect of possessing what one desires: delight: the expression or exhibition of such emotion [13].

2.2 Bhavah Algorithm

The flowchart of Bhavah has been explained below: -

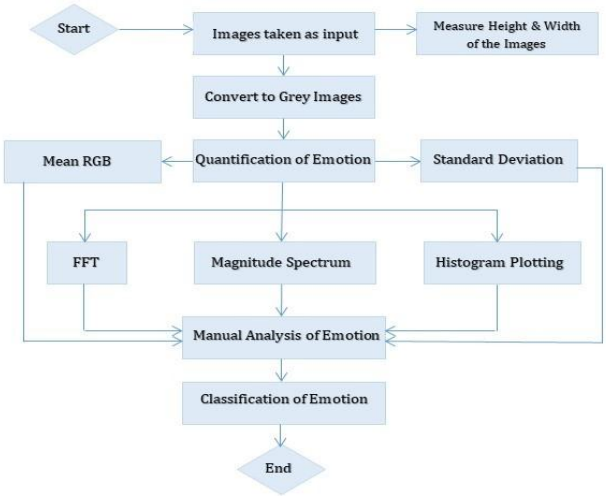

Fig -1: Algorithm of BHAVAH GRI 1427

The detailed descriptions of each sections of the Bhavah Algorithm are explained in the subsections below:-

2.2.1 Main Input Section

This section includes the declaration of python libraries: numpy, cv2, matplotlib and matplotlib.pyplot. It takes image as input in png format, on which quantifications will be done.

2.2.2 Conversion to Gray Scale Image

The image taken as input has three channels i.e. Red, Green and Blue or RGB. It increases the complexity of image processing. Hence in this section, Bhavah converts the three layer original image into gray scale which will be a one layer image from 0-255.

2.2.3 Quantification of Image

Each and every image has their own unique signatures with help of which we can identify or categorized them. We have used this concept to quantify and classify each image into six fundamental human emotions, mentioned in section 2.1, based on the following parameters.

2.2.3.1Mean BGR

In this section, Bhavah calculates the mean pixel value of the original input image. Since Bhavah has been developed in OpenCV Python environment, the output of this section comes in a reverse manner. Hence the output or the mean pixel values of the channels is in the order of Blue, Green and Red i.e. BGR instead of Red, Green and Blue or BGR. The main focus of this section is to find the dominant channel of the various human emotions, to quantify them. The biggest pixel value and the corresponding channel are being taken into accounts.

2.2.3.2Standard Deviation

This section calculates the amount by which the pixel values are differing from the mean gray scale value of the image. The values are being noted down for each images of that emotion. This process is repeated for other emotions. We eventually got specific range in which the standard deviation oscillates for each emotion.

2.2.3.3Histogram

Bhavah plots the histogram of the gray scale image. Then we observe the position of the peak in the plot. The positions have been broadly classified into left-sided, right-sided, mid-section, extreme right-sided or extreme left-sided. The position of the peaks is observed for various images under the same emotion, to find out any continuity in position of peaks exists or not for that emotion. This process is repeated further for other categories of emotions that have been mentioned in section 2.1. Fig. 2 below shows the histogram plot of a surprise face where the peak position is extreme right sided.

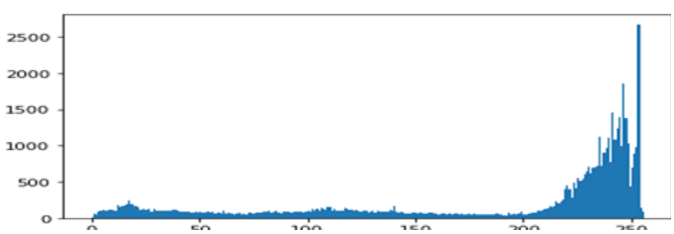

Fig -2: Histogram plot of a surprise face

2.2.3.4Fast Fourier Transform

In this section Bhavah plots the Fast Fourier Transform or FFT of the gray image. After that, the authors of the paper have examined the output manually. It has been seen that the shape of the central dark spot remains same for the emotion and shape changes for the other groups of emotion. Fig. 3 below shows the output of FFT for an image of a sad face. The central dark spot shape in this case is close to circular.

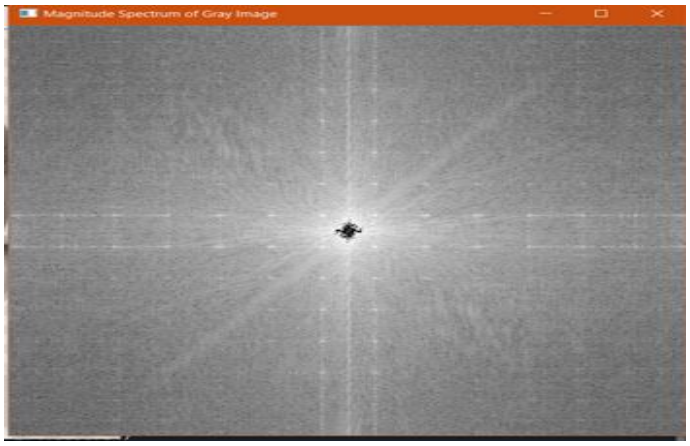

Fig -3: FFT of Sad Face

2.2.3.5Magnitude Spectrum

This section calculates the magnitude spectrum of FFT of the gray image. The value comes in the form of array. Hence Bhavah uses numpy library of python in this section. Fig. 4 below shows an output of magnitude spectrum for a face image.

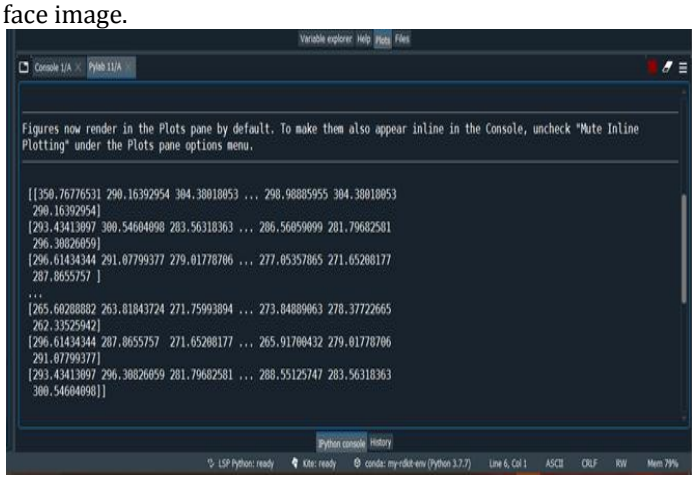

Fig -4: Magnitude Spectrum of an angry face

3. EXPERIMENT PERFORMED

We have repeated Bhavah algorithm on multiple images of each of the six emotions mentioned under section 2.1. Each of the outputs, then have been manually analyzed and investigated. The dominant channel, standard deviation values, position of histogram peak and shape of

central dark spot in FFT of each image has been noted down in six tables, each table representing each emotion. Finally, the six tables are analyzed and combined to form one final table showing quantification of each emotion.

4. EXPERIMENTAL RESULTS

As mentioned under section 3, six tables ranging from Table -1 to Table -6 shows the experimental results of each data, used in this research. Table -7 is the final results table of this research which includes quantification of six fundamental human emotions mentioned under section 2.1.

Table -1: Sadness Emotion Data Analysis

Data Set No	B	G	R	Standard Deviation	Histogram	FFT
Data Set 1	116.75	121.29	140.38	71.259	Mid-Section	Circle
Data Set 2	68.64	78.09	90.21	51.461	Left Sided	Circle
Data Set 3	166.32	170.32	176.76	80.7016	Right Sided	Circle
Data Set 4	99.68	99.68	99.69	51.52	Left Sided	Circle
Data Set 5	195.51	206.63	220.45	65.167	Right Sided	Circle
Data Set 6	177.34	185.09	200.4	74.76	Right Sided	Circle
Data Set 7	170.2	176.34	187.85	41.04	Right Sided	Circle
Data Set 8	126.58	141.49	146.8	52.99	Mid-Section	Circle
Data Set 9	163.45	173.9	210.99	40.38	Right Sided	Circle
Data Set 10	139.18	151.22	160.87	75.04	Right Sided	Circle

Table -2: Surprise Emotion Data Analysis

Data Set No	B	G	R	Standard Deviation	Histogram	FFT
Data Set 11	200.91	206.96	220.57	69.29	Extreme Right Sided	Asterisk
Data Set 12	178.62	185.74	191.22	78.64	Extreme Right Sided	Asterisk
Data Set 13	165.45	171.62	195.04	55.56	Extreme Right Sided	Asterisk
Data Set 14	162.01	162.62	166.17	49.58	Extreme Right Sided	Asterisk
Data Set 15	207.40	210.36	227.34	52.06	Extreme Right Sided	Asterisk
Data Set 16	198.14	206.83	225.42	59.11	Extreme Right Sided	Asterisk
Data Set 17	212.75	219.40	232.23	53.53	Extreme Right Sided	Asterisk
Data Set 18	201.45	204.51	210.82	40.43	Extreme Right Sided	Asterisk
Data Set 19	170.05	176.51	197.70	72.22	Extreme Right Sided	Asterisk
Data Set 20	205.18	200.25	215.07	29.09	Extreme Right Sided	Asterisk

Table -3: Anger Emotion Data Analysis

Data Set No	B	G	R	Standard Deviation	Histogram	FFT
Data Set 21	127.46	127.46	127.46	80.53	Right Sided	Ellipse
Data Set 22	58.92	54.35	116.31	49.50	Mid-Section	Ellipse
Data Set 23	86.75	95.31	99.28	63.58	Left Sided	Ellipse

Data Set 24	177.53	186.45	197.51	80.71	Right Sided	Ellipse
Data Set 25	61.90	81.10	90.17	57.19	Left Sided	Ellipse
Data Set 26	173.27	181.91	190.87	49.43	Right Sided	Ellipse
Data Set 27	163.06	162.62	171.43	102.73	Right Sided	Ellipse
Data Set 28	197.09	198.22	203.12	87.32	Right Sided	Ellipse
Data Set 29	185.29	183.98	185.57	58.92	Right Sided	Ellipse
Data Set 30	51.97	55.12	67.75	49.35	Left Sided	Ellipse

Table -4: Disgust Emotion Data Analysis

Data Set No	B	G	R	Standard Deviation	Histogram	FFT
Data Set 31	193.87	205.23	225.60	58.01	Right Sided	Cross Shaped
Data Set 32	150.84	153.96	164.92	83.65	Right Sided	Cross Shaped
Data Set 33	174.69	181.62	198.63	89.45	Right Sided	Cross Shaped
Data Set 34	107.68	116.86	126.65	47.56	Mid-Section	Circle
Data Set 35	153.56	160.10	172.08	46.16	Right Sided	Cross Shaped
Data Set 36	60.90	76.99	78.96	58.65	Left Sided	Cross Shaped
Data Set 37	181.68	181.68	181.68	51.57	Left Sided	Ellipse
Data Set 38	111.79	132.36	179.80	29.37	Mid-Section	Cross Shaped
Data Set 39	180.48	187.06	193.26	55.73	Right Sided	Cross Shaped
Data Set 40	182.29	183.33	181.41	54.45	Right Sided	Cross Shaped

Table -5: Fear Emotion Data Analysis

Data Set No	B	G	R	Standard Deviation	Histogram	FFT
Data Set 41	140.42	156.28	172.32	76.23	Right Sided	Longitudinal + Ellipse
Data Set 42	153.44	152.10	172.78	69.50	Right Sided	Longitudinal + Ellipse
Data Set 43	192.67	195.17	199.42	36.62	Right Sided	Circle
Data Set 44	174.15	173.60	177.45	33.79	Right Sided	Longitudinal + Ellipse
Data Set 45	109.21	136.29	78.58	30.12	Mid-Section	Longitudinal + Ellipse
Data Set 46	155.76	160.56	165.57	91.64	Right Sided	Longitudinal + Ellipse
Data Set 47	100.25	103.01	110.13	54.95	Mid-Section	Longitudinal+ Ellipse
Data Set 48	145.50	144.40	151.27	49.93	Mid-Section	Ellipse
Data Set 49	192.63	202.47	223.12	60.02	Right Sided	Longitudinal + Ellipse
Data Set 50	158.61	158.78	169.31	75.29	Right Sided	Longitudinal + Ellipse

Table -6: Happy Emotion Data Analysis

Data Set No	B	G	R	Standard Deviation	Histogram	FFT
Data Set 51	188.66	193.92	209.56	70.13	Right Sided	S Shaped
Data Set 52	185.71	188.82	197.31	59.97	Right Sided	S Shaped
Data Set 53	193.80	200.65	212.52	52.65	Right Sided	S Shaped

Data Set 54	202.24	211.98	221.72	39.93	Right Sided	Circle
Data Set 55	198.69	212.23	226.67	45.16	Right Sided	S Shaped
Data Set 56	150.61	156.62	170.86	80.50	Right Sided	Ellipse
Data Set 57	195.34	204.75	228.84	53.06	Right Sided	S Shaped
Data Set 58	142.76	165.35	153.09	52.75	Mid-Section	Longitudinal Ellipse
Data Set 59	161.41	184.05	205.50	42.87	Mid-Section	S Shaped
Data Set 60	137.64	143.26	161.50	50.63	Mid-Section	Circle

Table -7: Final Table for Quantification of Emotions

Emotions	Dominant Channel	FFT Type	Standard Deviation Range	Histogram Shape
Sad	Red (100%)	Circle (100%)	50 – 64 (50%)	Right Sided (70%); Left Sided (20%); Mid-Section (10%)
Surprise	Red (100%)	Asterisk (100%)	40 – 60 (80%)	Extreme Right Sided (100%)
Anger	Red (100%)	Ellipse (100%)	49 – 63 (60%)	Right Sided (60%)
Disgust	Red (90%) Green (10%)	Cross Shaped (80%) Circle (10%) Ellipse (10%)	40-51 (60%)	Right Sided (60%); Mid-Section (20%); Left Sided (20%)
Fear	Red (90%) Green (10%)	Longitudinal+Ellipse (80%); Circle (10%); Ellipse (10%)	50 – 70 (70%)	Right Sided (70%); Mid-Section (30%)
Happy	Red (90%) Green (10%)	S Shaped (60%); Circle (20%); Ellipse (10%); Longitudinal+Ellipse (10%)	45 – 53 (80%)	Right Sided (70%); Mid-Section (30%)

5. CONCLUSIONS

Bhavah have been developed with an ultimate aim of helping researchers and doctors identify human beings who have face abuse, maltreatment and violence along with the patients who have been diagnosed with PD or HD diseases. In turn this will help doctors to start treatment accordingly. **Thus, Bhavah indirectly will prove to be an important technology to help in improving the life of human in the aspects of psychology and physiology**. Many research works has been done in past which uses deep learning or cross modal bias techniques for identification of facial emotions. The authors of this paper have tried to classify emotions using an exclusive methodology termed as "Quantification of Emotions" in this research. However, Bhavah is a semi-autonomous system with manual works need to be done for investigation of outputs. If analysis section of Bhavah could be turned into autonomous, it would help in saving time and giving more efficient and accurate analysis. The results of the parameters: Mean, Standard Deviation, Histogram and FFT, could be used for Hyperparameter optimization for better training of deep neural networking model to give more accurate prediction of emotions.

"**BHAVAH GRI 1427**" code and experimental dataset is available at:
https://github.com/EmotionRecognitionSystem/Emotion_Recognition_System_using_Quantification_Analysis

ACKNOWLEDGEMENT

The authors would like to thank Dr. Prabir Banerjee, the Head of the Department and Dr. Shounak Dasgupta, the Departmental Coordinator of Electronics and Communication Engineering, Heritage Institute of Technology, Kolkata. We also would like to thank our

parents for being the unending support, strength and inspiration in our lives.

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