Facial Emotion Recognition through TFERA

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Abstract - This research paper is focused to study the expressions on the human face and infer the human emotions from thermal facial images. The basic human emotions are happiness, sadness, anger, surprise, neutral and fear. Earlier research have analyzed and identified these emotions from visible facial images. The research had its drawback of using the visible facial images in the visibility of emotions on the images captured in varying illumination and pose variations. Poor illumination hinders the calculation of the actual expression shown on the face. Fake expressions shown by the person in the image can always lead to the wrong identification of expressions. To overcome the drawbacks in using visible facial images in emotion recognition, this research have used thermal images for emotion recognition. The proposed algorithm TFERA proved to be successful in identifying emotions in poorly illuminated areas and also to overcome the fake emotions shown in visible images.

Keywords *- TFERA; Thermal images; Visible Images; Image Registration; ROI; Emotion Recognition.*

I. INTRODUCTION

Human emotions may be a resultant of various psychological factors that may or may not be revealed. Thus a human facial expression is a spontaneous outcome of a significant interactions or emotion, which can be expressed through their head motion, behavior or partial occlusions. Thus recognizing the expressions from these measures proves to be challenging in the development of automated facial expression recognition system. The research to identify whether human beings can show a common expression to express their emotions started in 1950's. The expression varied from the people of different culture and places [14]. The research further proved that particular emotions with an exception that the faces from literate cultures showing specific emotions were highly judged by people from a preliterate culture with a less opportunity to have learned to recognize uniquely western facial expressions.

Analysis and recognition of facial expression is a research subject for psychologists from 1970s, which led to advanced research accomplishments such as face detection, tracking and recognition. Face recognition plays a major role in tracking the expressions in a face, but pattern recognition problem proved to be complex. The face has meaningful and multidimensional visual stimulus. Identifying the features representing a face and classifying a new face image based on the representation was a typical pattern recognition problem. The feature representation approaches used are Eigen faces, Principal Component Analysis (PCA), Gabor Wavelet features, Linear Discriminant Analysis (LDA), Local Binary Patterns (LBP) and Independent Component Analysis (ICA). These patterns can be efficiently used to train machine to detect facial emotion by assigning a weighing function and develop a multi cultural facial emotion translation system. Thus recognizing facial expressions by computer was developed by Paul Ekman et.al 1976 [15] a procedure to measure visibly different movements of face, deriving facial action code to analyze the anatomical basis of facial movement. Thus evolved automatic expression recognition system that identifies the basic emotions such as anger, happiness, surprise and sad.

The expression identification was a real task for system when images are captured in poor illumination and in pose variation by the subjects. Thus the percentage of expression recognition depends on the quality of the image and the illumination and pose during the capture of the image. These disadvantages of using of using a visible image for emotion recognition can be overcome by using thermal images, since the emotions are studied in thermal images through the variations in the heat levels in throughout the facial region.

II. LITERATURE SURVEY

Facial emotion recognition deals with the deformation of facial features from the visibly seen features from visual images. Facial expressions can be learned from the temporal measures such as onset, apex and offset that are used or coding but did lack in precision. Facial Electromyography [9] computes the onset and offset parameters of facial expressions. Behavioral Psychologists studied the facial features [2] by positioning certain facial features within the regions of interest from the facial images. The features were used to determine the rotational and translation displacement of head pose by measuring the center of one eyeball to the corresponding eyeball that lead to the detection of eye gaze direction for the eye [6].

Personality perception was based on the behavior of full body [10] rather than focusing the action units of face. High quality and controlled static images are used for facial feature extraction due to logistical reasons [1] [23].

Most of the facial expression recognition map facial expressions on to the categories of archetypal emotions that make the emotion recognition complex in images that shows no emotions [18]. The problem was solved through FACS framework [17] which is a model based analysis that overcomes the disadvantage but the framework was highly dependent on the illumination quality of the images [21].

The classical method of using eigen faces [13] was used in stereovision technique to acquire three dimensions [5] of facial image using two cameras to implement an algorithmic chain to convert two dimensional spaces of two images acquired from two cameras into 3D data of human face, which is the requirement of virtual reality [22] related applications. Johel Miteran et all, 2007 [11] has proposed a technique based on multi-processor approach that allows embedding and reconfiguring process to find the depth map of face [24]. The approach was precise and reliable for applications related to multimedia, virtual worlds and biometrics. The major drawbacks in using visual images were solved by using thermal images which can capture real expressions and identify the emotions within a person through the measurement of heat variations. The performance statistics of identification and verification of faces on visible and thermal images based on Monte Carlo analysis of performance measures are listed by Diego et al. 2003 [8]. The analysis proved that under many circumstances thermal images yield higher performance when compared with visible images.

III. PROPOSED METHODOLOGY

Visual learning approach is based on the selection of suitable regions for feature extraction and extracts Gray Level Co-occurrence Matrix (GLCM) to compute region descriptors. Support Vector Machine (SVM) classifiers are used to classify the emotions

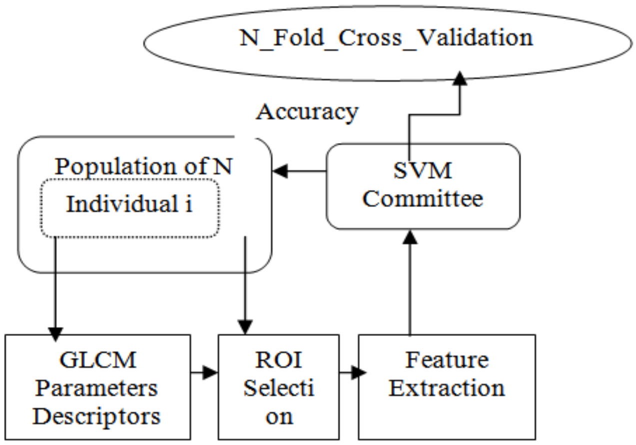

Figure 1: Visual Learning Approach

The cross validate accuracy outperforms human classification by an average of 16% which is a promising result because the learning approach is independent of how the regions are defined and the type of image used to extract features. [3].

The proposed Thermal Facial Emotion Recognition Algorithm - TFERA is mainly focused to determine the emotions from thermal images. Real time face library is used in developing TFERA. Thermal images have the temperature intensity variations shown by two colours blue and red. The temperature is measured in different regions of interest (ROI) based on the pixel intensity of blue and read colour in those regions. The temperature shows variation in different ROI for different emotions. Therefore mapping of those temperatures onto the ROI has identified the emotions almost accurately.

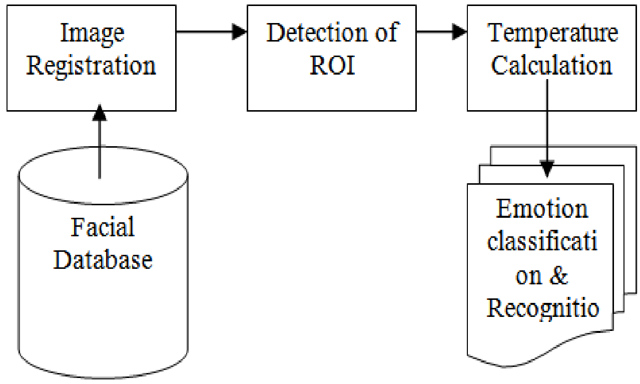

Figure 2: Proposed Thermal Facial Emotion Recognition System

Researchers have strongly stated that facial actions have great impact on the emotion activation process that involves the nature of expression. Activation of an emotion through referent loop or cerebral blood flow can resist the direct empirical validation [4]. Although humans can control there expressions naturally, blood flow to certain regions due to their inner emotions happens naturally. Stress level can be quantified [7] through the thermal signature by measuring the blood volume between a baseline and a Stroop Session [19]. Therefore, with this study the proposed algorithm TFERA was developed. The emotions were traced in thermal images through the temperature variations around the selected ROI such as periorbital, nasal, left cheek, right cheek and chin. The emotions showed a different in the temperature map in these regions. The proposed algorithm works in two phases: images processing and classification.

IV. EXPERIMENTS AND RESULTS

The proposed thermal facial emotion recognition algorithm consists of four major stages that include:

- Image Registration
- Face Detection
- Calculation of Facial Temperature
- Emotion Recognition

A. Face Library - Real time face library was used in this proposed method. The images were captured from 10 subjects in varying situations. The face library was collected with FLIR E8 thermal camera that has an IR Pixel Resolution 320 x 240 with thermal sensitivity < 0.06^0C and temperature range of -20 to 250^0C. The subjects were asked to not show any visible emotions such as anger, happiness, surprise etc., since analyzing a visible emotion such as laughing and identifying the emotion as happiness is easier, but to find the hidden emotion is the real task in this algorithm.

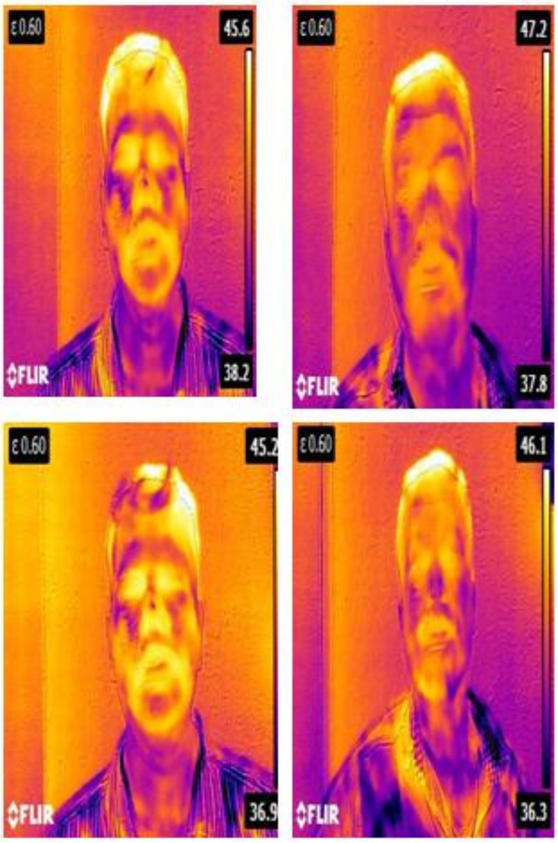

Figure 3: Thermal Facial Images

B. MATLAB - MATLAB R2014a is used for the study of emotions from facial images. The research tool is proved to be highly appropriate for image processing since MATLAB programming language provides a wide environment in design, modeling, simulation and testing with higher level functions that speed up the development of advanced applications. Also MATLAB is more appropriate in calculations when compared to other scientific tool such as LabVIEW [20].

C. Image Registration - Image registration technique is used to align and integrate images captured in same scenario at different times, may be of seconds, days, months or years. The different scenario also can be capturing images at same time with different devices, thus with different resolution.

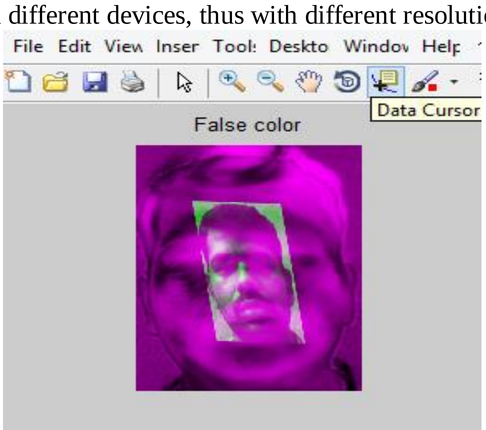

Figure 4: Image Registration

The time difference helps us to overcome the issues such as image scaling, rotation and skewing during the image capturing process [16]. In a 2D image with a size denoted by I1 and I2 there I1(x,y) and I2(x,y) map to their respective intensity values, then the mapping between images can be expressed as:

$$I_2(x,y)=g(I_1(f(x,y))) \longrightarrow \quad (1)$$

where f is a 2D spatial coordinate transformation as:

$$(x',y')=f(x,y) \longrightarrow \quad (2)$$

and g is one dimensional intensity or radiometric transformation [12]. The problem in image registration is finding the optimal spatial and intensity transformation so that the images can match with regard to the source. Geometric transformation is represented as two single-valued functions fx,fy.

$$I_2(x,y) = I_1(f_x(x,y), f_y(x,y)) \longrightarrow \quad (3)$$

also expressed as a pair of separable function as:

$$F(x,y) = f1(x) \circ f2(y) \longrightarrow \quad (4)$$

where f2 is applied to each row and f1 is applied to each column.

Transformation T is linear which is represented as,

$$T(x1 + x2) = T(x1) + T(x2) \longrightarrow \quad (5)$$

and,

$$c\,T(x) = T(cx) \longrightarrow \quad (6)$$

Global transformation map straight lines into straight lines, therefore linear is commonly used in registration transformation to match two images of a scene taken from the same angle of view and from different position.

D. Facial Temperature and Emotion Recognition - The temperature of body is a measure of the heat rid by the body that is maintained even when the temperature around changes. In hotter temperature, the blood vessels in our skin widen to carry excess heat to the skin surface, thus sweating helps to cool the body temperature. Similarly, in cooler temperature, the blood vessels of the skin narrow to reduce the blood flow to the skin.

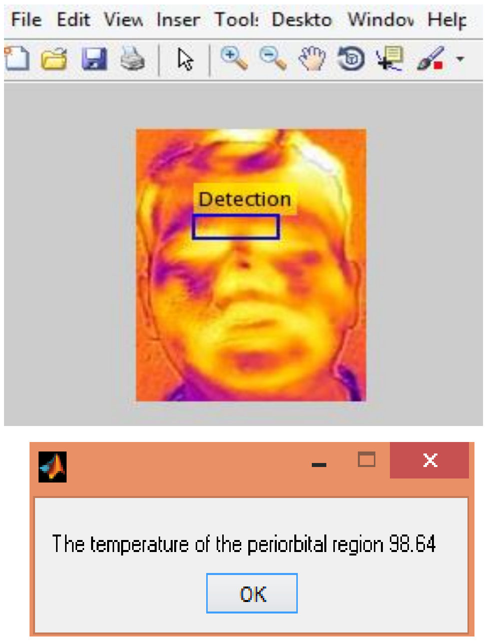

Figure 5: Detection of ROI and Calculation of Temperature

The algorithm works on five different ROI which are detected and cropped to analyze the pixel intensity in those regions. Intensity discontinuity is measured in the points, lines and edges that help to calculate the sum of the coefficients of the products using the intensity level in those regions of interest. KNN classifier with the help of trained samples and emotions were used to map and detect the facial emotions.

Table 1: Distribution of Facial Temperature

Image	Periorbital	Left Cheek	Right Cheek	Chin	Nasal
1	99.14	99.76	99.85	100.16	99.4
2	99.21	99.8	99.87	100.36	99.25
3	99.75	99.82	98.71	100.1	99.18
4	97.61	98.52	99.64	99.77	99.15
5	98.09	98.71	99.81	100.48	98.39
6	95.57	101.14	100.74	100.6	95.6
7	96.12	101.74	101.8	101.45	93.26
8	97.44	99.18	100.68	101.77	99.67
9	90.47	92.1	100.07	99.99	99.82
10	92.03	94.31	100.16	100.89	101.41
11	100.47	99.37	100.01	99.62	99.3
12	96.2	99.95	99.69	97.94	99.01
13	99.3	99.81	98.42	99.12	99.44
14	90.95	99.15	99.32	96.23	97.58
15	90.9	100	99.64	100.33	100.75
16	99.95	98.43	99.81	100.62	100.18
17	99.68	98.77	101.16	100.57	98.39
18	99.67	99.33	100.38	99.67	97.96
19	100.01	98.36	100.04	100.8	99.89
20	99.97	98.49	101.72	96.49	101.12

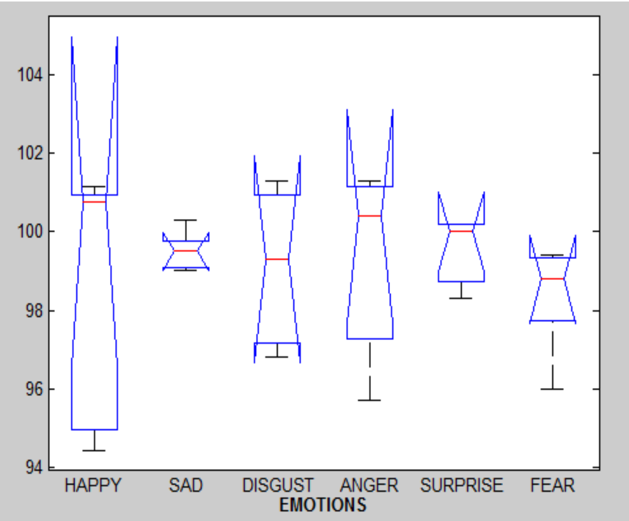

Figure 6: Analysis of Variance Test

V. CONCLUSION AND FUTURE WORK

The proposed algorithm FTERA is a novel approach in recognizing emotions from facial thermal images. The experiments were conducted on the real time face library captured from 20 subjects on various environments. The emotions recognized are happiness, sad, disgust, anger, surprise and fear. The results have proved to be accurate and reliable in calculating the temperature and interpreting the emotions. The algorithm can be applied to perceive human emotions more accurately and respond appropriately to the user's affective states, therefore more useful in security zones with behavioral psychology. The algorithm had certain limitations within such as the ambient temperature and its impact on the body temperature, normal human activity that rise the body temperature, drugs taken and so on. Thus the future enhancement in the algorithm will focus to explore new promising ideas to overcome the limitations.

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