A REVIEW ON HUMAN FACIAL EMOTION RECOGNITION SYSTEM

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***Abstract* - Emotion recognition being one of the hot topics of many research efforts and being useful in so many commercial and scientific fields. Emotion recognition concerns the extraction of facial features from static facial images and classifying the facial expressions namely, happy, sad, disgust, surprise, fear, and anger. Facial expressions are non verbal approach for communicating information between one people to another. Emotion in images is one of the powerful sources of high-level semantics. Human facial emotion recognition can be used for recognizing expression occurring in a people faces. The effective and efficient methods are needed for recognizing the emotions of human. The goal of this work is to study various existing recognition methods of FER system. In this research, presents a detailed insight on existing works and the methodologies used by researchers for recognizing the human expressions. Comparison among different human facial emotions by similarity systems is particularly challenging owing to the great variety of techniques implemented to represent likeness and the dependence that the results presented of the used image dataset. This will be helpful to the researchers for their future research direction in this area.**

***Keywords*– Preprocessing, Face detection, Feature Extraction, Classification, Facial Emotion Recognition**

I. INTRODUCTION

Image processing is a growing technology and can be used in a various fields like optical imaging, medical imaging, computer vision, computer graphics etc. It is a method that takes image as input and performs some operations on it and gives image attributes or image as output. The input image may be a photograph or video frame (considered as two dimensional signals) and the output may be the parameters related to that input image. The output image is produced the useful information. Digital image processing enhances the image by modifying its image qualities. Operations of image processing are divided into image enhancement, restoration, segmentation, extraction and recognition.

Recently still image-based human emotion recognition has become an active research topic in computer vision and pattern recognition. The result of various research studies indicates that the success of emotion recognition problems highly depends on the appropriate feature extraction process. It focuses on identifying a person's emotion from a static image. Unlike the traditional emotion recognition approaches where videos or image sequences are used, a still image contains no temporal information for emotion characterization. Thus the prevailing spatio-temporal features for video-based action analysis are not appropriate for still image-based emotion recognition. Detecting facial emotions from still images remains a challenging problem, and researchers are focused on studying this problem using various techniques. Therefore it is demanding to develop robust and efficient methods for still image-based emotion recognition to understand. Based on the emerging research in recent years, it is time to review the existing approaches to still image-based emotion recognition and inspire more efforts to advance the field of research [4].

Most of the existing works focus on classifying six basic facial expression categories (happiness, sadness, disgust, surprise, fear, and anger). Facial emotion recognition is an important area in human-computer interaction and digital entertainment. Due to the large diversity of human face, size, appearance, posture, patterns, occlusions and illumination changes, besides the complexity of human emotions, the task of automatically recognizing human emotions is very challenging [2].

A FER system comprises important phases like preprocessing, face detection, feature extraction and classification of emotions. A dataset should have well defined emotion tags of facial expression for recognizing the emotions in FER. The dataset such as JAFFE, CK+, FER 2013 have eight common facial emotions: Neutral, Sad, Happy, Disgust, Anger, Contempt, Surprise, and Fear. Image preprocessing is an important phase in facial emotion recognition system. The processes involved in preprocessing are image scaling and data normalization. After preprocess the image, to detect and crop the face region. Detecting faces in images is complicated because human faces are characterized by different gestures, expressions, positions, skin tones, hair, and differences in camera quality, gain, and image resolution. Due to the complex challenges of environment and emotional expression, most facial emotion recognition systems cannot achieve high recognition rates [5].

Facial feature extraction is a key technology to improve the accuracy of facial expression recognition. The process of extracting facial features including a person's eyes (eyebrows and eyes), nose, and mouth (lips and chin). The movements of these facial features define facial expressions that identify a person's emotions. Selecting these features related to human facial emotion classification is an important task in human facial emotion recognition research. Each person's facial expression should be different in different contexts such as lighting, posture, and even background [4]. All of these factors remain a problem in recognizing facial expressions. Researchers try to identify the minimal set of features that can achieve good classification performance. After learning the features, the final step in FER is to classify the images into one of the basic emotion categories. Fig. 1 shows an overview of the FER system.

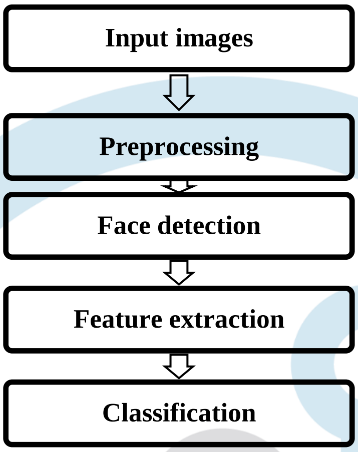

Fig. 1 Overview of the FER system

This section contains the introduction of image processing and fundamental theories for human emotion recognition system. Next section covers the literature survey of emerging techniques for human emotion recognition system as well as several extended work in these areas. Final section concludes the human emotion recognition techniques and identifies the future directions in this field.

II. LITERATURE SURVEY

To better understand Human Facial Emotion Recognition System, it is useful to review and examine the existing research works in literature. Therefore, recent approaches and methodologies used for recognizing emotions from images have been discussed.

Amit Pandey, Aman Gupta, and Radhey Shyam [1] has proposed a convolutional neural network and edge detection approach. The edge in image of each layer is retrieved in the convolution process after the facial image is normalized. To preserve the texture features, the retrieved edge information is placed on each feature image. This paper uses a Haar classifier for human face detection and enhances the calculation speed by using integral graph method to calculate the Haar like values. It’s suitable for face detection problem in the training phase because it gives high detection accuracy and also reduces the computation complexity. The extracted facial feature gives inputs to the classification module which finally categorizes different emotions. In this research, different datasets are investigated and explored for training expression recognition models. The purpose of this paper is to make a study on face emotion detection and recognition via machine learning algorithms and deep learning.

Devashi Choudhary and Jainendra Shukla [2] had reviewed 25 articles and implemented 18 different facial features such as LBP, LDRHP, LBPH, LDSP, HOG, Gabor Filter, SVD, GLCM, SIFT, Shape, Edge and Texture features for FER and examined the most notable feature using three feature selection methods such as Joint Mutual Information, Conditional Mutual Information Maximization and Maximum Relevance Minimum Redundancy and applied the machine learning methods such as MLP and BoVW on the CK+ dataset. All the feature selection methods showed the use of approximately 20% of identified total features as an optimal number of features for FER. The results reported an accuracy of 84.53% using a formal approach and 85.9% using the Bag of Visual Words model approach. In this work, they had explored grey comatrix and haralick features for the first time for the FER. One limitation of this study that it only focused on the classification of basic emotions like happy, sad, fear, etc. and another limitation was only used one dataset.

Hivi Ismat Dino and Maiwan Bahjat Abdulrazzaq [3] had presented an automatic system of face expression recognition which was able to recognized all eight basic facial expressions such as normal, happy, angry, contempt, surprise, sad, fear and disgust and CK+ dataset was used. Viola-Jones algorithm was used for face detection, Histogram of Oriented

Gradients descriptor used for feature extraction and Principal Component Analysis applied to reduce the dimensionality of the features for feature selection. Finally, three different classifiers such as Support Vector Machine, K-Nearest Neighbor and Multilayer Perceptron Neural Network were used for classification of facial expressions and the results were compared. The experiment results showed that the Support Vector Machine proven to be a better classifier.

M. Kalpana Chowdary et al. [4] had proposed two feature extraction techniques such as mouth region based feature extraction and maximally stable external regions method. In mouth based feature extraction method, Viola Jones mouth detection was used and mouth area was calculated based on morphological operations and then based on the value, the emotions were classified. In the maximally stable external regions method, the Viola Jones face detection was used and features were extracted using connected components and Artificial Neural Network algorithm was applied for classification. The experimental results showed that the maximally stable external region based feature extraction method outperforms well.

K. Krishnaveni and G. Radha Priyadharsini [5] had analyzed the face detection and face alignment challenges such as pose variations, the camera distance from the face, and the lighting changes in an image. The face was detected and aligned using the ensemble of regression tree techniques. The aligned face region was connected and cropped with the boundary of the landmark points using Delaunay triangulation method for feature extraction and two types of feature fusion methods such as Histogram of Gradients + Local Directional Pattern and Histogram of Gradients + Local Binary Pattern + Grey Level Co-occurrence Matrix were used to crop face images. These features were fed into three classifiers such as Error Correcting Output Codes, K-Nearest Neighbor and Discriminant Analysis to recognize six facial expressions. The error correcting output code model achieves better accuracy.

Mayyadah R. Mahmood [6] had provided a comparative approach between two feature selection methods such as Chi-Square test and Relief-F. In this paper, the highest six ranked features from 784 features were selected through two feature selection methods and then the selected features were applied in four classifiers such as Support Vector Machine, K-Nearest, Decision Tree and Radial Base Function. The objective of this paper provided approach to use minimum number of features to classify the emotions from CK+ facial emotion recognition dataset. The result of the experiment demonstrates that K-Nearest Neighbor was the most accurate classifier among the four for both feature selection methods.

Mayyadah R. Mahmood et al. [7] had provided a performance evaluation of a set of supervised classifiers used for FER based on minimum features selected by chi-square test. The best high ranked six features from chi-square test were applied on six classifiers including Multi-Layer Perceptron, Support Vector Machine, Decision Tree, Random Forest, Radial Baised Function and K-Nearest Neighbor and the experimental outcomes demonstrate that Random Forest illustrates the most accurate and efficient classifier among the rest in facial emotion recognition using CK+ dataset [7].

Milan Tripathi [8] has analyzed the very best model among the three models including AlexNet, VGG19, and ResNet50 used to train the facial emotion recognition dataset. The VGG19 model is trained using various optimizers and evaluated based on its training and testing accuracy, confusion matrix, ROC curve and K-fold. The experiment results showed that the VGG19 based CNN model performs well among all the other proposed models. They suggested the transfer learning and complex feature extraction techniques may increase the accuracy.

Muhamad Fatchan et al. [9] had performed the following stages such as preprocessing stage (the image was converted into grayscale), face detection (Viola Jones face detection algorithm was used), feature extraction (Principal Component Analysis algorithm was used) and facial emotion classification (Support Vector Machine and Neural Network algorithms was used). Comparison between the prediction models such as Neural Network and Support Vector Machine of emotions including anger, sad, happy and surprise. The Support Vector Machine method outperforms well and gives better accuracy.

Phavish Babajee et al. [10] had explored the recognition of human facial expressions through a deep learning approach using a Convolutional Neural Network algorithm. This system used for labeled data set containing around 32,298 images with different facial expressions for training and validation. The pre training phase involves face detection with noise removal using Viola Jones algorithm and feature extraction using two methods such as analytic approach and holistic approach. The holistic approach takes the global properties of the patterns while the analytic approach computes a set of geometrical features based on feature vectors. Finally, the extracted features were fed into the classification model for emotion recognition.

Wasan. Maddah Alaluosi [11] had performed the following three stages such as preprocessing stage was performed to enhance the facial images, feature extraction stage depended on Discrete Wavelet Transform and Discrete Cosine Transform methods and recognition stage was applied using an Artificial Neural Network, known as Back Propagation Neural Network, on CK dataset which consists of 90 images of 10 persons with three expressions including happy, sad and surprise. The numeric pixel values (x,y) of the features in each image was an input to Neural Network for recognition of facial expressions. The accuracy of recognition for each emotion as follows: 91.12% for happy, 90.31% for sad and 94.5% for surprise.

The focus of this review is to summarize the various existing human emotion recognition techniques as shown in Table 1.

Table 1. Summarization of Various Human Emotion Recognition System Methods

<table>
<tr><th>Literature</th><th>Dataset</th><th>Pre Processing</th><th>Face Detection</th><th>Feature Extraction and Selection</th><th>Classification Accuracy (%)</th></tr>
<tr><td>Amit Pandey, Aman Gupta, Radhey Shyam [1]</td><td>FER 2013</td><td>Edge detection, Normalization</td><td>Haar Classifier</td><td>Feature base and Appearance base</td><td>CNN – 89.50
SVM – 97.98</td></tr>
<tr><td>Devashi Choudhary, Jainendra Shukla [2]</td><td>CK+</td><td>Resize (64x64), Gaussian Filter</td><td>RCNN</td><td>LBP, Gabor Filter, Shape features, SVD, Edge filters, GLCM, SIFT</td><td>MLP – 85.9</td></tr>
<tr><td>Hivi Ismat Dino, Maiwan Bahjat Abdulrazzaq [3]</td><td>CK+</td><td>Resize (640x480)</td><td>Viola Jones</td><td>HOG with PCA</td><td>SVM – 93.53
KNN – 82.57
MLP – 79.97</td></tr>
<tr><td>M. Kalpana Chowdary, D.Jude Hemanth, A. Angelopoulou, E. Kapetanios [4]</td><td>JAFFE</td><td>Resize (164x164)</td><td>Viola Jones Face detection, Viola Jones Mouth detection</td><td>MSER, Morphological operations</td><td>ANN – 89,
Mouth Region Segmentation – 86</td></tr>
<tr><td>K. Krishnaveni, G. Radha Priyadharsini [5]</td><td>JAFFE and CK+</td><td>Face alignment method</td><td>Facial landmark detection</td><td>HOG+LBP+GLCM,
HOG+LDP</td><td>Error Correcting Output Codes – 83.78
KNN – 78.37
Discriminant Analysis – 75.67</td></tr>
<tr><td>Mayyadah R. Mahmood [6]</td><td>CK+</td><td>Noise Removal and resize (28x28)</td><td>Viola Jones</td><td>Haar like features with Chi Square Test and Relief-F</td><td><table><tr><th></th><th>Chi square test</th><th>Relief – F</th></tr><tr><td>J48</td><td>92.87</td><td>92.27</td></tr><tr><td>KNN</td><td>94.18</td><td>94.43</td></tr><tr><td>RBF</td><td>90.38</td><td>89.65</td></tr><tr><td>SVM</td><td>90.48</td><td>89.43</td></tr></table></td></tr>
<tr><td>Mayyadah R. Mahmood, Maiwan B. Abdulrazzaq, Subhi R. M. Zeebaree, Abbas Kh. Ibrahim, Rizgar R. Zebari, HiviIsmat Dino [7]</td><td>CK+</td><td>Noise Removal and resize (28x28)</td><td>Viola Jones</td><td>Haar like features with Chi Square Test</td><td>J48 – 92.87
KNN – 94.18
RBF – 90.38
SVM – 90.48
MLP – 92.09
RF – 94.28</td></tr>
</table>

Milan Tripathi [8]	FER 2013	Resize (48x48x1), Normalization	Image rotated, shifted, zoomed, sheared and shifted	VGG19	CNN – 91.89504
Muhamad Fatchan, Mauridhi Hery Purnomo, Affandy, Ahmad ZainulFanani, Linda Marlinda [9]	JAFFE	Gray scale conversion, Normalization	Viola Jones	PCA	NN – 85 SVM - 87
Phavish Babajee, Geerish Suddul, Sandhya Armoogum, Ravi Foogooa [10]	FER 2013	Cropping, Gray scale conversion	Viola Jones	Haar like features and Geometric features	CNN – 79.8
Wasan. Maddah Alaluosi [11]	CK+	Resize (250x250), Sharpening, Median filter	LL frequency sub band	DWT, DCT	ANN with DCT – 91.9 ANN with DWT – 87.5

III. CONCLUSION

Automatic human emotion recognition has been one of the challenging issues in computer vision in recent years. Facial expressions are universal, regardless of race, culture, ethnicity, national origin, gender, age, religion, or any other demographic variable. It is of great importance in various applications in Artificial Intelligence like video surveillance, criminal investigation and human computer interactions. When studying the related work on this issue, it has been found that the human emotion recognition system can be designed by the following steps of processes such as preprocessing, face detection, feature extraction, and emotion classification.

The review aims at automating FER system processing for recognizing the human expressions from an image dataset. This paper presents a survey on various human emotion recognition techniques that was proposed earlier by researchers for the better development in the field of human emotion recognition system. All these techniques have their own advantages; In other words, there is not a single technique that fits best in all categories of human feelings. The authors had attempted to sum up the methods and techniques used to recognize the human emotions. It will be helpful to the researchers to understand and compare the related advancements in this area.

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