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Neural Network-Based Expression Recognition System for Static Facial Images

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Abstract

Affective Computing is a field of studying the human effect to interpret, recognize, process, and simulate in computer science, psychology, and cognitive science. Humans express their emotions in a variety of ways such as body gesture, word, vocal, and mainly facial expression. Non-verbal behavior is a significant component of communication, and facial expressions of emotions are the most important complex signal. Facial Expression Recognition (FER) is an interesting and challenging task in artificial intelligence. FER system in the study three steps including preprocessing, feature extraction and expression classification. In the paper, comparative analysis of expression recognition is implemented based on Neural Network (NN) with three feature extraction methods of Sobel Edge, Histogram of Oriented Gradient and Local Binary Pattern. NN-based expression recognition system achieves an accuracy of 95.82% and 97.68% for JAFFE and CK+ dataset respectively. The result has shown that the Edge features are the effected features for recognizing human expression using still images.

Keywords: facial feature; neural network; sobel edge; expression classification.

1. Introduction

FER system is an important research work for analyzing human emotions using facial expression data. Detection and recognition of human effect can be used in the applications of the E-learning system, psychological health services, robotic system, social monitoring and communication with autism people.

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The machine should interpret the emotional state of humans so it can adapt the behavior and response to these emotions. Facial expression is a significant channel to describe emotions. The purpose of the research is to develop an emotion recognition system from facial images using Sobel edge detection method and Neural Network (NN) classification. In the paper, related works are described in section 2 and the detail of the datasets involves in section 3. The proposed network is explained in section 4 and finally concluded in section 5.

2. Related Work

D.M. Aung and N. Aye's paper [1] used a morphological based method along with a histogram for facial expression recognition system to classify five expressions happy, anger, neutral, surprise and sad. In the preprocessing, the median filter is used to reduce noise and then segments the mouth and applied morphological processing. The distance features of mouth edges are extracted as geometric features using the method. A histogram calculation used in the last stage as a classifier. The limitation of the paper is that the system used only geometric features and five classes of emotion expressions. Yang and colleagues [2] proposed an emotion recognition model for a distance learning system to detect the facial expressions of students. In the paper the authors used the Haar Cascades method to detect eye and mouth, Sobel Edge detection to filter and detect edge features and Neural Network for classification. JAFFE facial expression dataset is used to test the model accuracy for six basic expressions: happiness, surprise, anger, fear, sadness, and disgust. The edge features of the eyes and mouth is useful to recognize the facial expressions. In [3] paper, Hybrid feature descriptors for feature extraction and added codebook construction are used to detect emotion. The two classifiers K-nearest neighbor and Support Vector Machine with polynomial, linear, and radial basic function kernels are used to classify the expression on JAFFE and CK+ datasets. The performance of the model depends on numbers of detected features, levels of image segmentation, the number of clusters for codebook generations, and the size of the training data set. The paper of Sang [4] also proposed a deep Convolutional Neural Network for seven human expressions: angry, happy, fear, disgust, surprise, sad and neutral. To avoid the over-fitting problem, the authors applied data augmentation after the preprocessing step. Data Augmentation contains mirror the image, rotate the image, rescale the image, and take a random crop from the rescaled image. Cross entropy and L2 multi-class SVM are used to evaluate the model. The decision is that trick of data augmentation will be important in training a deep neural network in the future. Reference [5] explored a model Weighted Center Regression Adaptive Feature Mapping (W-CR-AFM) for facial expression recognition. The paper used a Convolutional Neural Network for feature training and then transforms the feature distribution of testing samples. The light CNN can outperform with the preprocessing and AFMs. AFM will be deployed for a real-time system by learning batch by batch instead of calculation all training and testing data in one batch. Qi and his colleagues [6] proposed a new approach for facial expression recognition based on cognition and mapped binary patterns. Segmentation of face is a useful technique for emotion recognition so the system divided the face into six sub-regions. The mapped local binary pattern is used to extract the features and reduce the dimension of these features. Convolutional Neural Network is used as a classifier for expression recognition. Moreover, the authors also compared the basic emotion model with the circumplex emotion model using SVM and softmax. The eyes and mouth can distinguish the expressions mainly. The result appears that the circumplex emotion model works well than the discrete model. Improved Local Binary Pattern, Shabat's paper [7] proposed an approach Angled Local Directional Pattern (ALDP) including center pixel information. ALDP achieves

better accuracy than state-of-the-art without preprocessing. Six types of classifiers k-NN, SVM, DT, RF, Gaussian NB, and Perceptron are applied to experiment on the CK+ dataset. The study used only handcrafted features for expression classification. Sreedharan and his colleagues [8] proposed a facial expression recognition system based on Grey Wolf Optimization (GWO) feature selection method. Viola-Jones algorithm is used to detect facial parts such as eyes, nose, mouth, and ears. In the feature extraction step Scale Invariant Feature Transform (SIFT) is used and then the optimal features are selected by applying GWO-based feature selection method. JAFFE and CK+ benchmark datasets are used to recognize seven facial expressions such as normal, smile, sadness, surprise, anger, fear, and disgust using GWO-based NN classifier. Munir and his colleagues [9] proposed a recognition system to explore the illumination problem of real-world facial images. To enhance the image from poor illumination, Fast Fourier Transform and Contrast Limited Adaptive Histogram Equalization (FFT+CLAHE) methods are used and then applied Merged Binary Pattern Code (MBPC); 16-bit code per pixel with two bits per neighbor. The dimensions of the extracted features is reduced by using Principle Component Analysis feature select method. The dataset to perform experimentation is Static Facial Expression in the Wild (SFEW) including 700 images collected from videos with real-world reflection.

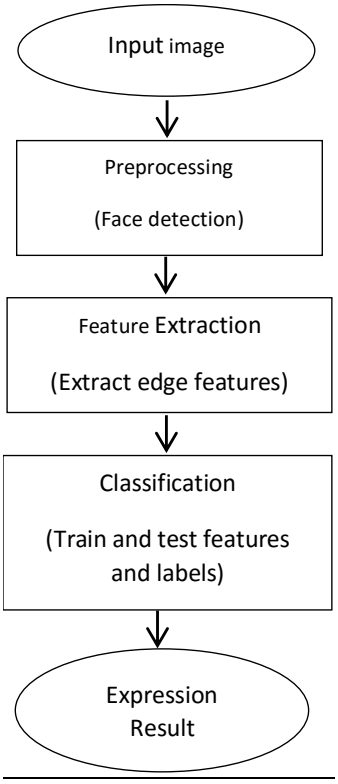

Figure 1: Facial Expression Recognition System

3. Dataset Description

Japanese Female Facial Expression (JAFFE) dataset [10] is a publicly available dataset that contains seven expression categories: six basic facial expressions such as sadness, happiness, anger, surprise, fear, disgust and neutral. There are static facial images posed by 10 Japanese women in the dataset. All of the images have a resolution of 256×256 pixels and they are gray images with tiff format. One of the public accessible datasets is

CK+ [12] that involves sequences of facial expression images acted by 123 subjects in the range of 18-50 years of age with the png file format. For the static image experimentation, the dataset setting up the last two frames for each subjects in all six basic classes. And the first frames of each subject are selected for the neutral class. Sample images of the two datasets are shown in Fig 2. The numbers of expression images in the two datasets are listed in table 1.

Figure 2: Seven expressions of JAFFE (top) and CK+ (down) datasets

Table 1: Number of images in JAFFE and CK+ datasets

	Sadness	Happiness	Angry	Surprise	Fear	Disgust	Neutral	Total
JAFFE	31	31	30	30	32	29	30	213
CK+	56	136	90	166	50	114	118	730

4. Proposed FER System

Recognition systems of facial expression images have basically three steps such as preprocessing, feature extraction, and classification shown in Fig 1. In the study, Viola-Jones face detection algorithm [11] is employed to detect the face using Haar-Cascades features in the preprocessing stage. Moreover, the detected facial images are scaled to get the same size 64 × 64 pixels and then the Sobel edge detection method is used to extract the facial edge features. The recognition of facial expression is performed to classify seven categories such as happy, angry, fear, disgust, neutral, surprise and sadness.

4.1. Face Detection

The face is not a multi-signal system but it gives multi-message to explore emotions from the facial image. Face detection is an important task for the facial expression recognition system. Viola-Jones face detection algorithm is used in the proposed system by using Haar features and Cascade classifier. The detected face image is prepared by scaling into pixels 64×64 dimension as shown in Fig. 3.

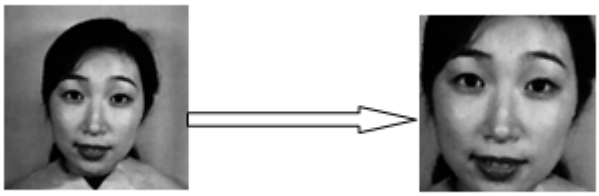

Figure 3: Detected face

4.2. Feature Extraction

Features are distinctive properties of input patterns that help in differentiating between the categories of input patterns. Methods of feature extraction can be divided into five categories such as edge-based method, texture features-based method, geometric feature-based method, global and local feature-based method, and patch-based method. Sobel Edge detection method is used to extract facial appearance features in the proposed system. The edges of the image are pixels where brightness changes abruptly. The edges are significant local changes in the image and are important features for analyzing images. One of the most commonly used edge detectors is Sobel method that is used in the study. The Sobel operator is the magnitude of the gradient computed by equation (1).

$$M = \sqrt{S_x^2 + S_y^2} \quad (1)$$

Where the partial derivatives are computed by (2) and (3).

$$S_x = (a_2 + ca_3 + a_4) - (a_0 + ca_7 + a_6) \quad (2)$$

$$S_y = (a_0 + ca_1 + a_2) - (a_6 + ca_5 + a_4) \quad (3)$$

With the constant c=2. The gradient operators S_x and S_y can be implemented using convolution masks as show in (4).

$$S_x = [-1, 0, 1; -2, 0, 2; -1, 0, 1]$$

$$S_y = [-1, 0, 1; -2, 0, 2; -1, 0, 1] \quad (4)$$

4.3. Classification

Classification is one of the main steps for the facial expression recognition system. In the study, the simple neural network is used to train and test the feature of the facial expression images datasets. The network is designed with the parameter of one hidden layer including 20 hidden notes and 20 maximum epochs. The

Neural Network design is shown in Fig 5 with the parameters. The validation method in the experimentation used 10 folds cross-validation to get the consistent processing result.

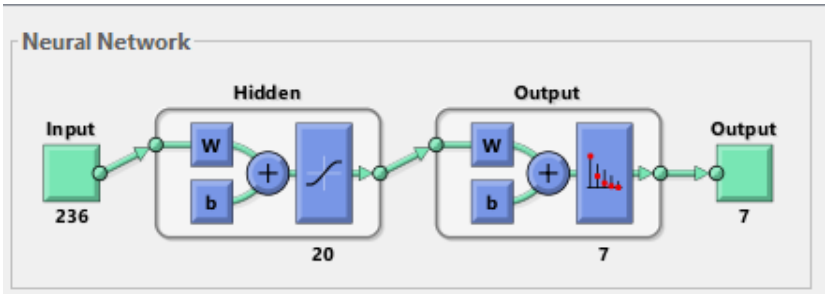

Figure 4: Design of Neural Network

The raw images from the dataset are input to detect the face using Viola-Jones face detection algorithm. The detected faces used for extracting edge features using Sobel operators. The edge features are trained and tested by using a neural network recognition system. The accuracy of the Sobel features and Neural Network classifier achieves better than Histogram of Oriented Gradient and Local Binary Pattern feature extraction methods without using the image enhancement or smoothing methods. The study designed for only static facial images to classify human facial expressions. The comparison results of three feature extraction methods based on Neural Network are shown in the table (1).

Table 2: Comparison Results based on NN Classifier

Feature Extraction Methods	JAFFE Accuracy (%)	CK+ Accuracy (%)
Histogram of Oriented Gradient	86.99	92.37
Local Binary Pattern	89.24	89.64
Sobel Edge	95.82	97.68

5. Conclusion and Recommendations

Facial expression recognition system is interesting and ongoing research work in computer vision for the application of human-computer interaction, distance learning system, psychological health services, robotic system, social monitoring and communication with autism people. The study presents a comparison of three low-level feature extraction methods such as HOG, LBP, and Sobel edge detection based on Neural Network classifier. The recognition results of Sobel technique with Neural Network classifier achieves 95.82% and 97.78% accuracy rate on JAFFE and CK+ benchmark datasets respectively. According to the results, the edge features is significant to detect the facial features related to human expressions. The research is only focus on handcrafted features and lab-controlled facial images. In the future, the study can be extended by adding image enhancement methods and smoothing methods in the preprocessing step and extracting deep features using a convolutional neural network.

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