Tikrit Journal of Pure Science Vol. 27 (2) 2022 TJPS

Tikrit Journal of Pure Science
ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)
Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Facial expression using Histogram of Oriented Gradients and Ensemble Classifier

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https://doi.org/10.25130/tjps.v27i2.67

ARTICLE INFO.

Article history:
-Received: 30 / 6 / 2021
-Accepted: 8 / 9 / 2021
-Available online: / / 2022

Keywords: Facial Expression, HOG, JAFFA, an ensemble classifier

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ABSTRACT

In this research, two methods were proposed to design a new system to recognize facial expressions. The first method relies on extracting features from the face area, and the second method relies on the process of extracting features on the parts of the face (eyes, nose, and mouth) where the histogram of oriented gradients (HOG) algorithm was used in the feature extraction process in addition to the principal component analysis algorithm to reduce feature dimensions in both methods. We have proposed a group classifier consisting of three basic classifiers: support vector machines, knn-algorithm closest to neighbors, and Naive Bayes in the classification stage. Our proposed algorithm was tested on japanese female facial expression (JAFFE) Dataset and Cohn-Kanade (CK) dataset. It was found that higher overall accuracy is achieved for F1-Score when using the second method of 93.82 % and 94.12% for CK and JAFFA, respectively.

I. INTRODUCTION

The face recognition method has the fascinating problem of image processing and computer vision. Facial recognition is generated by input face image and the saved face image of the recognized face. FER can be used to analyze the human state, such as in the driving situation. The emotional state is neutral, happy, sad, angry, fearful, surprised, and disgusted. The FER research can be divided into facial expression detection and facial muscle action detection. The research has imperative applications for human-computer interaction, medical treatment, and virtual reality[1][2].

This paper proposes a Facial Exepression Recognition system using machine learning that constructs ensemble classifiers based on JAFFA and CK datasets. The proposed solution focuses on feature analysis and classification, where feature analysis uses the histogram of oriented gradients (HOG) features, and Principal component analysis (PCA) is extracted from each facial region. The main objective is to find an approach that can introduce the low-dimensional features representing the human face with enhanced discriminatory power. Then, support vector machine, k-nearest neighbor algorithm, Naive Bayes classifiers are used as ensemble classifiers to recognize a certain person's facial expression.

II. OVERVIEW OF FACIAL EXPRESSION

The facial recognition process is an action that humans implement regularly and easily in our everyday lives. The individual recognition for the face that appears in the input data is the face recognition process.

There are four operations in the facial recognition system: pre-processing, face detection, feature extraction, and facial recognition. The main goal of this study was to investigate the performance through HOG, PCA, and a new ensemble classifier using a support vector machine, k-nearest neighbor algorithm, Naive Bayes classifiers. Figure1 gives an overview of facial expression recognition systems.

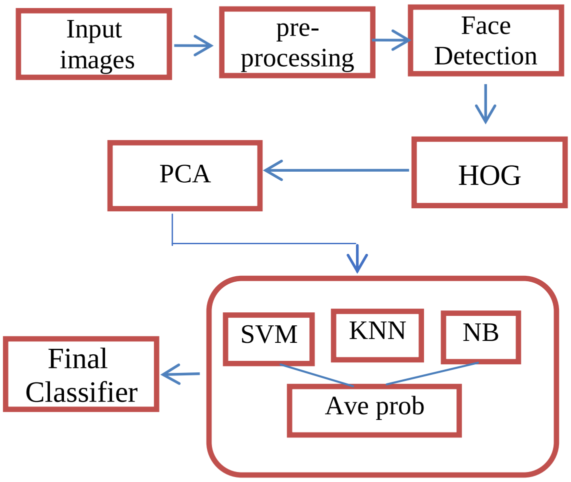

Fig. 1. Overview Of Facial Expression System

III. PRE-PROCESSING

Pre-processing of an image is certain low-level operations that are performed on an image. Pre-processing is performed for one of two reasons, either to minimize noise and boost picture data that includes undesired distortions or to convert the image into another space where the classification method is rendered smoother by leveraging those attributes[3][4]. The Histogram Equalization (HE) approach is used in this article.

Face Detection

The method of face detection can be characterized by classifying an image area as "face" or "nonface." The different face detection processes can be described as 'picture-given, all sides thereof detect (if any), and their exact locations and dimensions locate[5].

The Viola-Jones method is used for facial detection that involves a complete vision of the frontal side and simple brightness changes in the object's properties [6][7]. The Viola-Jones façade detection technique comprises three principles that permit the best effective facial detector: the theory of the integral image of feature co-detection[7][8].

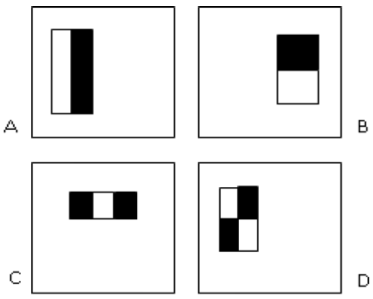

Fig. 2. haar like filter[7]

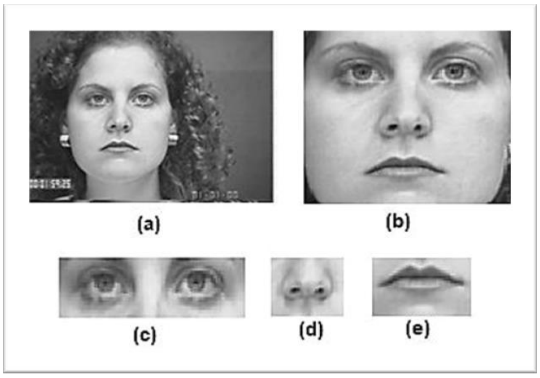

Fig. 3. Face detection and face parts detection

IV. FEATURE EXTRACTION

The general performance of the face recognition system depends primarily on the techniques used to retrieve facial features. In this article, the histogram of oriented gradients and PCA are used for feature extraction.

HISTOGRAM OF ORIENTED GRADIENTS (HOG)

The local aspect and shape of the object can often be defined by distributing local intensity gradients or edge directions, even though the corresponding gradient or edge location is not accurately known. This statement leads to the definition of the HOG technology, used in its mature form and widely used for human detestation in the Transformation of Scale-Invariant Features (Lowe 2004). (Dalal and Triggs 2005). The HOG descriptor is focused on the accumulation of gradient direction on the pixel of a spatially small area called the "cell" and the subsequent build-up of a 1D histogram whose combination provides the characteristics of the vector to be considered. Let L be a gray-scale function that describes the picture you want to analyze. The picture is divided into cells N by N and the orientation by N by x, and the gradient is calculated by the following rule in each pixel:[9][10]

$$\theta_{x,y} = \tan^{-1}\frac{L(x,y+1)-L(x,y-1)}{L(x+1,y)-L(x-1,y)}$$

Successively, the orientations θ^j_i i = 1 . . .N^2, i.e. belonging to the same cell *j* are quantized and accumulated into an M-bins histogram. Finally, all the achieved histograms are ordered and concatenated into a unique HOG histogram that is the outcome of this algorithmic step, i.e. the features vector to be considered for the subsequent processing[10][11]

In this article, it was proposed two algorithms to extract features based on HOG and PCA.

In the first algorithm, HOG, and PCA it was applied to the face area after performing the initial treatment process and determining the face area using the Viola-Jones algorithm, as shown in figure 4

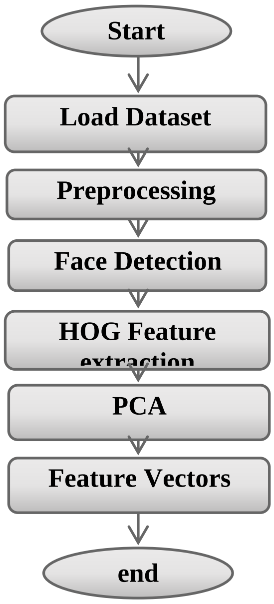

Fig. 4. Face HOG Principal Component Analysis (FHPCA)

In the second algorithm, HOG, and PCA it was applied to the parts of the face area after performing the initial treatment process and determining the parts of the face area (eye, mouth, and nose) using the Viola-Jones algorithm, as shown in figure 5.

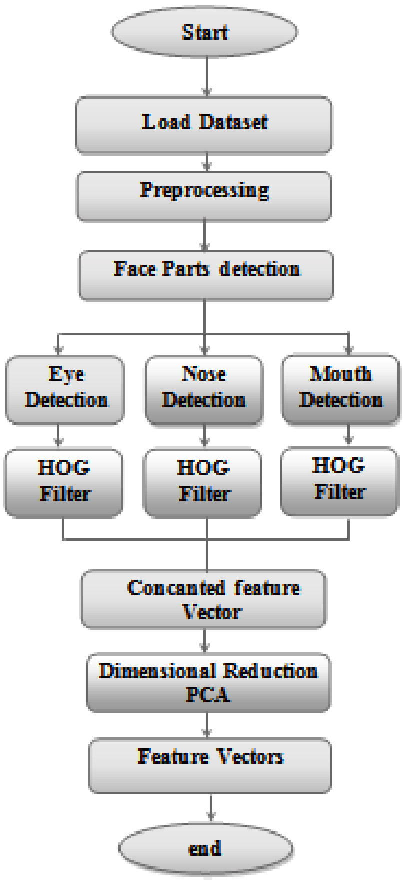

Fig. 5. Face Parts HOG Principal Component Analysis (FPHPCA)

V. Classification Stage

The final step in a facial expression recognition system is to categorize facial emotions. Face processing uses the feature vectors from the face. Facial features are used to group the features into various emotion categories[12].

Various machine learning methods could identify emotions in this paper; we use a support vector machine, k-nearest neighbor algorithm, Naive Bayes classifiers to create a new ensemble classifier.

Ensemble methods are learning algorithms that construct a set of classifiers (base classifiers) and then classify new data points by taking a weighted vote of their predictions[13][14].

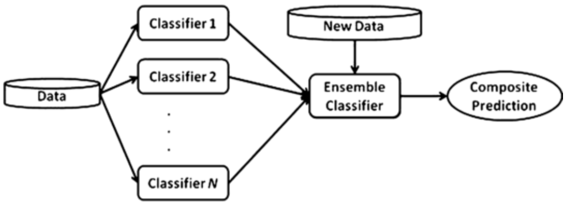

Fig. 6. ensemble classifier

VI. Results and Discussion

Facial Exepression Recognition (FER) models are tested through two datasets, CK and JAFFA, and results are evaluated with different evaluation metrics calculated depend on the Confusion matrix, namely, Precision, Recall. Precision shows the positive predictive value, and recall captures the model's sensitivity and true positive rate.

We split the dataset 70%, 30% split for the training and testing. To further understand and assess the models, we examined the metrics for each emotion by a confusion matrix, Figures 7and 8 show the confusion matrix for CK and JAFFA in the first method (FHPCA), and Figures 9and 10 show the confusion matrix for CK and JAFFA in the second method (FPHPCA), and tables 1 and 2 show the classification report for the first method (FHPCA)and tables 1 and 2 show the classification report for second method (FPHPCA).

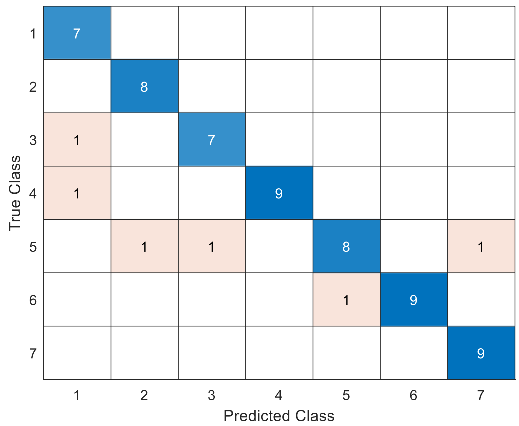

Fig. 7. FHPCA confusion matrix of 7-class facial of JAFFA

Tabel 1: FHPCA Classification Report of JAFFA

	Precision	Recall	F1_Score
1	77.77	100	87.50
2	88.88	100	94.11
3	87.50	87.50	87.50
4	100	90	94.73
5	88.88	72.72	80
6	100	90	94.73
7	90	100	94.73
Average of F1_Score			90.47

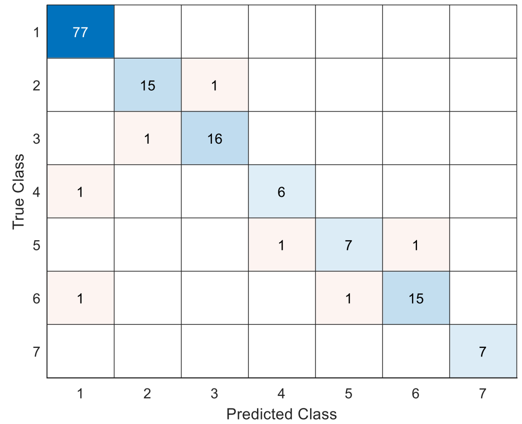

Fig. 8. FHPCA confusion matrix of 7-class facial of CK

Tabel 2: FHPCA Classification Report of CK

	Precision	Recall	F1_Score
1	97.4	100	98.7
2	93.7	93.75	93.75
3	94.1	94.11	94.11
4	85.71	85.71	85.71
5	87.50	77.77	82.35
6	93.75	88.23	90.90
7	100	100	100
Averag of F1_Score			92.22

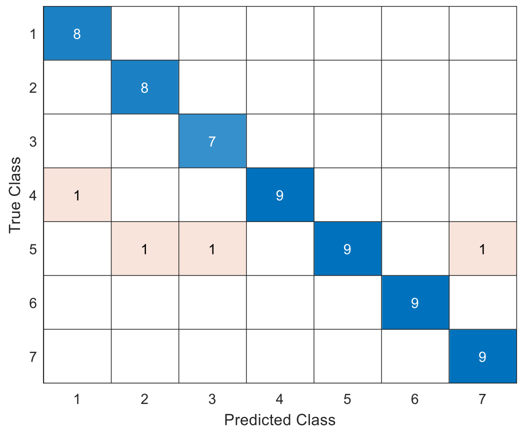

Fig. 9. FHPCA confusion matrix of 7-class facial of JAFFA

Tabel 3: FPHPCA Classification Report of JAFFA

	Precision	Recall	F1_Score
1	88.88	100	94.11
2	88.88	100	94.11
3	87.50	100	93.33
4	100	90	94.73
5	100	75	85.71
6	100	100	100
7	90	100	94.73
Average of F1_Score			93.8224

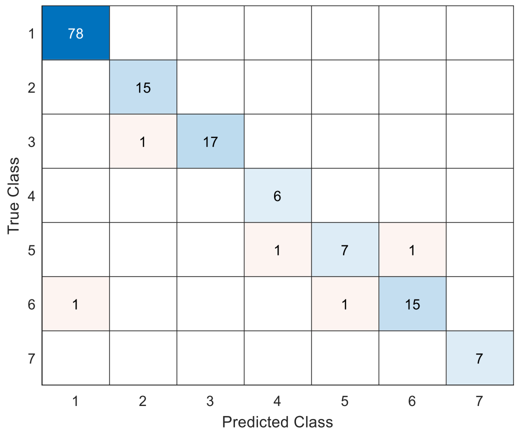

Fig. 10. FPHPCA confusion matrix of 7-class facial
Fig. 11. of CK

Tabel 4: FPHPCA Classification Report of CK

	Precision	Recall	F1_Score
1	98.73	100	99.36
2	93.75	100	96.77
3	100	94.44	97.14
4	85.71	100	92.30
5	87.50	77.77	82.35
6	93.75	88.23	90.90
7	100	100	100
Averag of F1_Score			94.12

CONCLUSION

Two methods for designing a new framework to identify facial expressions were proposed in this study. The HOG algorithm was used in the feature extraction process and the principal component analysis algorithm to reduce feature dimensions in both methods. The first method relies on extracting features from the face field, and the second method relies on extracting features from the parts of the face (eyes, nose, and mouth). In the classification point, we proposed a group classifier that consists of three basic classifiers: support vector machines, k-algorithm closest to neighbors, and Naive Bayes. JAFFA and CK Dataset were used to evaluate our proposed algorithm. The highest percentage of recognition was obtained using the second method (FPHPCA), where the overall accuracy for F1-Score was 93.82 percent for CK and 94.12 percent for JAFFA.

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تمييز تعابير الوجه باستخدام الرسم البياني للتدرجات الموجهة والمصنف التجميعي

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الملخص

تم في هذا البحث اقتراح طريقتين لتصميم نظام جديد للتعرف على تعابير الوجه. تعتمد الطريقة الأولى على استخراج الصفات من منطقة الوجه، والطريقة الثانية تعتمد على عملية استخراج الصفات من أجزاء الوجه (العين والأنف والفم) حيث تم استخدام الرسم البياني لخوارزمية التدرجات الموجهة (HOG) في عملية استخراج الصفات بالإضافة إلى خوارزمية تحليل المكون الرئيسي (PCA) لتقليل أبعاد الصفات في كلتا الطريقتين. لقد اقترحنا مصنفًا جماعيًا يتكون من ثلاث مصنفات أساسية: آلات ناقلات الدعمٍ (SVM)، وخوارزمية الجار الأقرب (KNN)، ونايف بايز Naive Bayes في مرحلة التصنيف. تم اختبار الخوارزمية المقترحة لدينا على مجموعة بيانات تعبيرات الوجه اليابانية (JAFFE) مجموعة بيانات (CK)وجد أنه يتم تحقيق دقة إجمالية أعلى لـ F1-Score عند استخدام الطريقة الثانية بنسبة 93.82٪ و 94.12٪ لـ CK و JAFFAعلى التوالي.