Facial Expressions Recognition Based on a Combination of the Basic Facial Expression Using Weighted the Local Gabor Binary Pattern (LGBP)

Fatemeh Gholami
MA Computer Engineering, Artificial Intelligence, department of computer, Islamic Azad university, Qazvin, Iran

Abstract
In this study, the Local Gabor Binary Pattern (LGBP) algorithm were used for facial expression recognition of emotion (happiness, sadness, anger, disgust, surprise and fear). As the topic of finding a strong feature has been studied by many research, in this work, we decided to focus on improving performance and features extracted more important features to get more accuracy of recognition.
The investigation came to the conclusion that considering the different weight matrix in the detection of facial expressions can be important parts of the face become more prominent. Therefore, the input image is partitioned into 9 equal area and extract the LGBP features. Then the entropy in each of those areas multiplied with the matrix derived features in areas where in areas where entropy is higher, like around the eyes, eyebrows and mouth vector Features with more effective and more affect Classifier.
KNN classifier is used in this research, which is used as a weighting fuzzy and without using fuzzy weighting. We reached in fuzzy mode 1.66 percent more accurate than other. Test results also confirms influence the partitioning of the area and using entropy weighting in areas.
Key-words:
LGBP, Entropy, Classifier, Fuzzy, KNN.

1. Introduction

Currently, with regard to technological advancements, facial expressions recognition has a lot of uses such as communication of humans with computers. With regard to extensive application in this field, automatic facial recognition has received significant attentions in recent years. Although there have been a lot of advancements in this field, facial expression recognition with high accuracy can be hardly achieved because of the existence of complexities and changeability of facial expressions.

Statement of the problem

The issue of facial expression recognition is one of the important issues discussed in machine artificial and visual intelligence, and different methods have been presented in this regard. Ekman’s studies in 1972 indicated that there are six basic emotions classes expressed regardless and independent of individuals’ cultures and races in the same facial expressions. These six 'classic' facial expressions of emotion are happiness, sadness, fear, anger, surprise and disgust [1]. Figure 1 illustrates four cases of basic emotions.

Facial expression recognition is conducted in three stages: 1. determining the area of the face and pre-processing, 2. Extracting features and selecting them, 3. Classifying facial expressions. The most important state in which facial expression recognition is conducted is extracting facial features. Determining the features of facial areas has significant effects on the efficacy of the facial expression recognition system. If features are incomplete or insufficient, the system cannot respond appropriately event in the best state of classification.

Despite a lot of studies conducted on facial expression recognition, there are a lot of challenges in this regard such as designing a real time and accurate algorithm for facial recognition, little resistance of facial features extraction algorithms against changes of lighting and noise conditions, little resistance of facial feature extraction algorithms against the existence of different eyeglasses, and different facial different makeup forms and very long beard or mustache, little resistance of facial feature extraction algorithms against different facial images of humans from each age, gender, and race, recognition of combinational and mixed facial expressions (happiness-surprise, sadness-surprise, sadness-fear, etc.).

The present research is aimed at presenting a method for human facial expressions of emotion using the Weighted LGBP and fuzzy logic in order to achieve better efficacy in this field. In addition to probing six basic facial expressions of emotion, the study is to investigate facial expressions of mixed emotions.

One of the most important cases in facial expression recognition is recognition mixed and combinational facial expressions. To this end, the present project is to use fuzzy logic because emotions are fuzzy in nature. One of the important stages in fuzzy logic affecting directly on the final results is fuzzification. In this stage, values of extracted features should be transcribed by fuzzy

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membership functions. For example, the degree of openness of eyes with three fuzzy membership functions are recorded as little, middle, and high openness. In fact, it determines the degree of our belief in the openness of eyes.

2. Research objectives

1. Suggesting a new methods using weighting LGBP and fuzzy rules
2. Using WLGBP for combinational facial expression recognition
3. Enhancing the accuracy of facial expression recognition in facial obstruction conditions and changes in brightness.

Hypotheses and research limitations

It is hypothesized that facial expression of emotion include 6 anger-hate-fear-joy-sorrow-surprise expressions.

1. It is hypothesized that facial expressions can be combinations of the mentioned 6 expressions (happiness-surprise, sadness-surprise, sadness-fear, etc.).
2. It is hypothesized that size and brightness are in different states.
3. It is hypothesized that facial images are different in terms of age, race, and gender.

3. Theoretical framework

General profile of facial expression recognition

Facial expression recognition is conducted in three stages: 1. determining the area of the face and pre-processing, 2. Extracting features and selecting them, 3. Classifying facial expressions. The most important state in which facial expression recognition is conducted is extracting facial features. Determining the features of facial areas has significant effects on the efficacy of the facial expression recognition system. If features are incomplete or insufficient, the system cannot respond appropriately event in the best state of classification. Selecting good features classifies efficiency. Therefore, how powerful features of pictures are selected should be paid attention to.

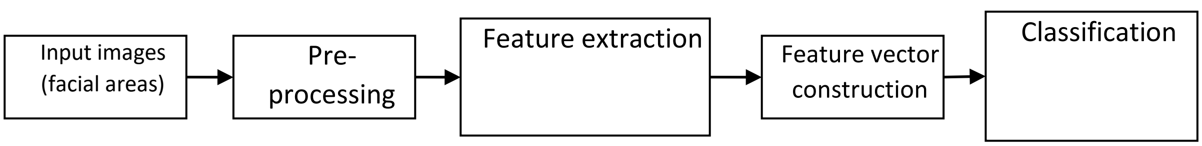


Fig. 1 general profile of facial expression recognition

Therefore, main stages of a face expression recognition system based on the visual machine method and using two-dimensional motionless images are as follows:

1. Imaging and determining facial areas

2. Feature Extraction for face

3. Feature Extraction using local binary pattern (LBP)

4. The method of GLBP

5. Feature extraction using GLBP

6. The HLAC method

7. Wavelet transform

8. The method of principal components analysis (PCA) in extracting facial features

9. The method WPCA in facial expressions recognition

10. The HAD in face recognition

11. Facial expression recognition feature extraction using Curvelet

12. The method of DCT / DWT in facial feature extraction

13. SIFT-based feature extraction

4. Image vector-based method

Classifiers used in facial expression recognition

Feature classification is the last stage in facial expression recognition. This stage is conducted after feature extraction in order to determine facial expressions. Below, some classification methods are presented:

K Nearest Neighbor (KKN)

One of the best classification is KKN. This classifier consider the test sample belonging to the class with the most ideas among its KKN. This method finds the nearest neighbor to the test sample from educational samples which is the Euclidean distance [11].

Generalized Discriminant Analysis (GDA)

This method suggests two-layered classification and produces two-dimensional and three-dimensional figures for facial expression recognition. The first layer consists of two GDA (GDA-L and GDA-S) which changes the three dimensional figures and apparent coefficients into three-dimensional figures and vectors of apparent features. The second layer consists of a DSA-L changes the connected feature vector into a feature vector of integrated facial expression. One-dimensional features are not sufficient for separating different expressions. This method is an appropriate stage which is the state of the divert face into the full-face state. This method includes several models each of which can match a limited range of selected states and requires the model of favorable face for entering face images [22].

Support Vector Machine (SVM)

It is one of the successful and powerful techniques for classifying facial expressions. The SVM is performed for facial expression recognition suing the extracted feature vectors. The SVM shows a virtual map of paths in a large scale which may be unlimited as the feature space and then, searches for a separating linear map for separating paths in this space with large dimensions [24].

Learning Vector Quantization (LVQ)

The LVQ is effective on facial expression recognition. It is one of the algorithms related to the nervous network. Previously, the Multi-Layer Perceptron was used instead of the LVQ. Previous methods had problems in classifying the expression of fear, but this method does not act appropriately in classifying the expression of fear. It is an unsupervised clustering algorithm acting based on the philosophy of winner-takes-all. Several versions of the LVQ exists among which the LVQ-1 has two competitive and output layers. Bashyal et al. used this version for clustering the feature vector of expressions and finally facial expression recognition.

Hidden Markov Model (HMM)

Another method for classifying facial expression is the HMM. It is based on a series of models constructed based on probability. If the density of conditional probabilities out of the current event is dependent only jn on the recent event, a process of the time field indicates a Markov feature. The HMM is a double random process indicated by a basic Markov chain with a few number of expressions and a set of random functions. This method can be used for classifying facial expressions.

1. Each transmission among expressions covers a couple of probabilities defined as follows:
   a. Transmission probability
   b. Output probability
2. This model is in very rich and powerful mathematical structures and is an effective model for temporary spatial data. This model is called the hidden model because only a sequence of observations can be observed via it.

This model includes algorithms such as Baum-Welch and Viterbi for evaluating, learning, and decoding. It is expressed via λ=(A,B,Π) and is explained as follows:

- A set of observations $O = \{o_1, \dots, o_T\}$ where $t = 1, \dots, T$
- A set of N expressions $\{s_1, \dots, s_N\}$،
- A set of k discrete view icons
- An expression-transition matrix $A = \{a_{ij}\}$ where the transition probability from is from S_i in the time of t to S_j in t+1
- An expression-transition matrix $B = \{b\_jk\}$ where b_{jk} production probability of icon v_k from expression s_j
- A primary probability distribution for expressions

3. Generalized Topology from a HMM is a completely connected structure where an expression can obtain from another expression.
4. When the HMM is used in Dynamic Gesture Recognition, as indicated in the figure, the expression index moves from left to right because of the passage of time.
5. The starting expression is indicated with S_1 and the final expression is shown with S_5 for N=5 in the figure.
6. This model is usually used for facial expression recognition. Firstly, a two dimensional image is taken from a three-dimensional model and a set of input features are tentatively extracted. Then, facial expression recognition is investigated using the HMM [25]. Figure 6-2 indicates the 5 expression Markov chain.

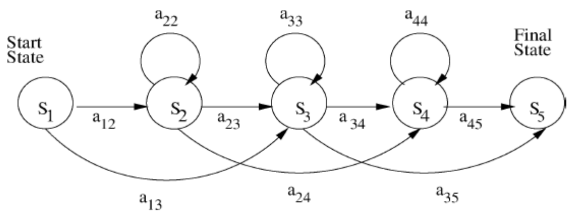


Fig. 6-2 The five expression Markov chain for facial expression recognition

5. A review of facial expression recognition systems

For facial expression recognition, a lot of systems have been used:

1. Gabor facial expression recognition in images with facial obstruction

2. Recognition of facial expressions based on fuzzy support vector machine and k-nearest neighbor

3. Recognition of facial expressions based on a combination of expressions and basic intensities

4. Recognition of facial expressions based on a two-step feature extraction

5. Gabor wavelet-based face recognition using PCA and LBP

6. Local Gabor binary patterns of three orthogonal design for the automatic face recognition mode

7. Recognition of facial expressions based on spectral analysis with multiple features

8. Fixed display of facial expressions in recognition of combinational expressions in unknown subjects

9. Recognition of facial expressions by FSVM and KNN

10. A versatile model for face detection and recognition of facial expressions

11. A set of neural network groups in recognition of facial expressions

12. Recognition of combinational facial expressions based on the expression types and its severity

13. A new compilation of the PCA and the LDP for feature extraction of facial expressions

14. The use of multiple guided filters and tuning Bayesian for facial expressions recognition

Research method

One of the most important cases in facial expression recognition which should be considered is combinational facial expression recognition. To this end, fuzzy logic was used in the present study because the natural of emotions is fuzzy. One of the important stages in fuzzy deduction affecting directly on the final results is fuzzification. In this stage, the values of extracted features should be written by fuzzy membership functions.

Facial expression recognition is conducted in three stages:

1. Determining facial areas and pre-processing
2. Extracting features and selecting features
3. Classifying facial expressions

The algorithm used for facial expression recognition is explained as follows:

In the present project, firstly images were pre-processed. Then they were partitioned into equal area. After that, the local binary pattern and Gabor filter were performed in each area and the features extracted from them were saved in a feature matrix. In addition, using entropy method, the significance of each area was obtained by an equation. With regard to the degree of entropy, a weight was obtained for each area. Finally, using the fuzzy method, facial expression recognition was investigated. Figure 3-1 indicates the flowchart of executive stages of the suggested algorithm.

1. Firstly, pre-processing is conducted (color images are changed into grey ones and normalization, etc. are conducted on them).
2. Then, images are partitioned into 9 equal areas and important features of each of them are extracted by the local binary pattern and Gabor filter. Then, values are saved in feature matrices.
3. In the entropy stage, each area is calculated (entropy indicates complexity and significance of each image). The more the entropy of each area, the higher the significance and details of each area. Therefore, that area is weighted with bigger scores.
4. The weights obtained from the previous stage are multiplied in the feature matrix. Then, using fuzzy method, images are classified with regard to their feature matrices in order that individuals' facial expression can be recognized out of facial images.

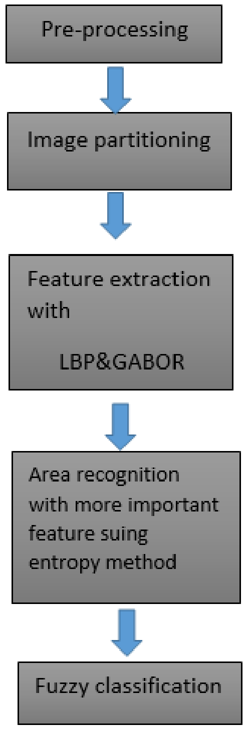


Fig. 3-1 The flowchart of executive stages of the suggested algorithm

Software and hardware requirements

The research experiments were administered on the 2010 version of MATLAB. Since requirements of the present study is not the implementation speed, but it is accuracy of algorithms; therefore, much need was felt for hardware devices with high processing power. Thus, a seven-core system with 8GB memory and with windows 7 was employed.

Different algorithms and methods are compared using different criteria in order that the superiority of one method over the other or the influence of one parameter on the other can be evaluated. Among the most important criteria in using research are algorithm accuracy and algorithm execution speed. The criterion of evaluation in the present study is accuracy of methods in terms of percentage.

In addition, for reporting each result, 10 fold experiments were conducted. It means that classification was conducted 10 times and each time, the training and test data were randomly selected. The average reported result is 10 times execution of each experiment.

Introducing the databases

In the present research, the most famous databases used in image processing were used, which is a Japanese database employed specifically for facial expressions. The Japanese Female Facial Expression (JAFFE) Database includes 213 images (including 6 basic emotional expressions and a normal expression) of the faces of 10 Japanese women. Each image were scored for being placed in an emotional rank. Figure 1-4 shows the instances of the JAFFE.

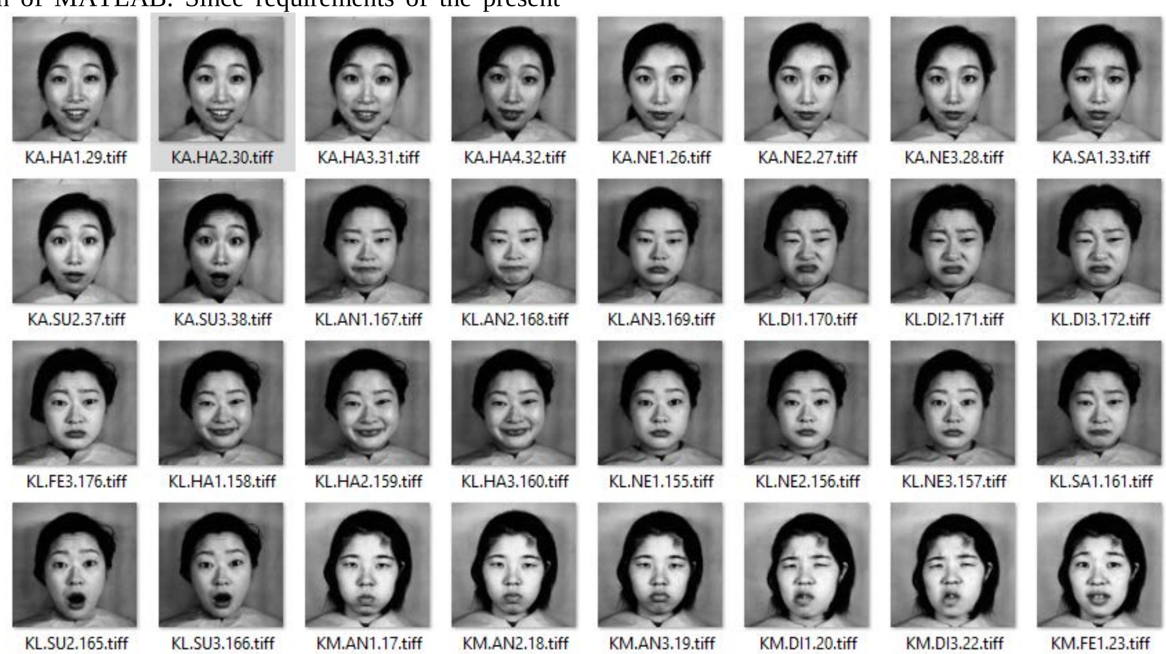


Fig. 1-4 Instances of images of the JAFFE

Designing experiments for facial expression recognition

In this stage, to explain the suggested model, we need to compare basic methods and the claim of increasing the increase of the suggested accuracy and the degree of influence of considered parameters. To do so, we conducted several experiments.

1. Recognition of facial expressions based on basic states face combined with the use of LBP

2. Recognition of facial expressions based on a combination of base states face using Gabor filter

3. Recognition of facial expressions based on basic states face combined with the use of LBP and Gabor No image segmentation

4. Introducing the suggested method: the recognition of facial expressions by combining basic scenarios using the LBP face with Gabor weighted image segmentation

The method used in feature extraction	Experiment	Row
[6] LBP	M1	1
[12] Gabor	M2	2
[43] Gabor +LBP	M3	3
[8] weighting + image partitioning + Gabor +LBP	M4	4
Attention: with regard to the issue that classifiers are used both in fuzzy and non-fuzzy ways in the present study, the mentioned experiments are stated in MXY form where X is related to the number of experiment, Y is related to Fuzzy, and C is related to non-Fuzzy experiments. M1F: experiment number 1 with fuzzy classifiers on the JAFFE M1C: experiment number 1 with non-fuzzy classifiers on the JAFFE		

6. Results of the experiments

Table 1-1: Results obtained from different experiments in fuzzy classifiers

Execution stages	M1	M2	M3	M4
1	70.00	86.67	96.67	96.67
2	76.67	83.33	93.33	100.00
3	53.33	90.00	90.00	100.00
4	60.00	93.33	96.67	96.67
5	56.67	83.33	93.33	90.00
6	60.00	83.33	83.33	93.33
7	53.33	86.67	80.00	93.33
8	53.33	86.67	93.33	100.00
9	66.67	80.00	86.67	96.67
10	43.33	83.33	90.00	93.33
Mean	59.33	85.67	90.33	96.00

Table 1-2: Results obtained from different experiments in non-fuzzy classifiers

Execution stages	M1	M2	M3	M4
1	50.00	76.67	80.00	96.67
2	46.67	83.33	93.33	96.67
3	53.33	83.33	93.33	100.00
4	63.33	80.00	73.33	86.67
5	50.00	83.33	90.00	93.33
6	60.00	83.33	96.67	96.67
7	66.67	86.67	80.00	90.00
8	63.33	83.33	90.00	100.00
9	66.67	80.00	86.67	93.33
10	46.67	73.33	96.67	90.00
Mean	56.67	81.33	88.00	94.33

To compare the degree that which expression are mistaken with each other, Confusion Matrix-CM can be used. To compare the two case of experiments under CM1 and CM2, the CM3 is suggested.

CM1

	Ha	Su	Sa	Fe	Di	An	Ne
Ha	100	0	0	0	0	0	0
Su	0	80	0	0	0	0	20
Sa	0	0	81.82	9.09	0	0	9.09
Fe	0	0	0	91.67	8.33	0	0
Di	0	9.09	9.09	18.18	63.64	0	0
An	0	0	0	10	10	80	0
Ne	0	0	0	0	0	0	100

CM2

	Ha	Su	Sa	Fe	Di	An	Ne
Ha	100	0	0	0	0	0	0
Su	0	80	0	20	0	0	0
Sa	0	0	90.91	9.09	0	0	0
Fe	0	0	0	100	0	0	0
Di	0	0	9.09	9.09	81.82	0	0
An	0	0	0	10	0	90	0
Ne	0	0	0	0	0	0	100

CM3

	Ha	Su	Sa	Fe	Di	An	Ne
Ha	100	0	0	0	0	0	0
Su	0	98	0	2	0	0	0
Sa	0	0	89	3	0	0	8
Fe	0	0	0	91.7	6	2.3	0
Di	0	0	3.70	8.21	88.09	0	0
An	0	0	0	3	0	97	0
Ne	0	0	0	2.7	0	0	97.3

From the three CMs, it can be identified that the distinguishability of the mentioned happiness expression is high and the three CMs identified it without correctly. It can be concluded that lips and mouths in loughs has high distinguishability and are not confluent with other expressions. In SU state, in CM1 and CM2 with normal and fear expression, errors were significant. But the degree of errors in our experiments was very low and only in the normal expression was mistaken with the fear expression and highlighted the effects of the partitioning and weighting which could distinguish the expressions appropriately. In the sadness expression, our algorithm could not do better and did errors like other algorithms with fear and normal expressions. The highest rate of errors was in Di where all three algorithms had the worst results of themselves in such a way that in the hatred expression is mixed with a significant degree of fear and sadness expressions. This issue was expected because this expression does not have necessarily an expression and can be a mixture of several expressions. It can be said that the Ha expression (lough) was not available in any other expressions in the dataset.

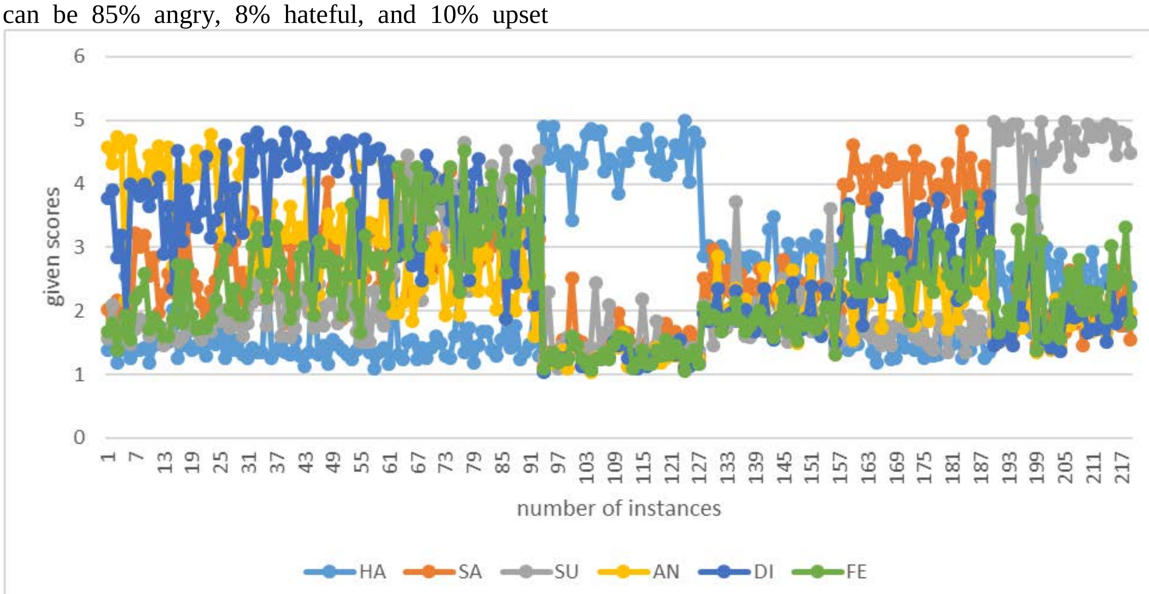
This question can be asked why a face is labeled Ha and the other is labeled as Di? Has the algorithm mistaken in facial expression recognition?

The answer to these questions are as follows:

To label each face in this data, 60 experts of this filed scored each face in each expression and the maximum facial label was the score of those 60 experts. For example, a face can be 85% angry, 8% hateful, and 10% upset which we have labeled angry. Therefore, it can be concluded that CMs can be expressed instead of considering the errors of classifiers. The question can be presented as follows: how much a facial expression is mixed with other facial expressions?

We can conclude from these three CM that with which expressions different facial expressions can be mixed. But this conclusion can be conducted with the used data. It can be said that the happiness expression is a single expression and cannot be mixed with other expressions. The SU expression (surprise) is mixed with fear. The upset expression is mixed with the fear expression. The Fe expression (fear) is mixed with a hatred expression. The Di is a mixture of hatred, fear, upset, and surprise expressions. The anger expression is with fear and hatred expressions.

For another conclusion, to recognize mixed facial expressions, the database should be investigated differently. In the JAFFE, each image is scored. This mean value is scoring system from 1 to 5 for each of the expressions given by 60 experts. The final column indicates the real label given to each instance of the image.



In the above chart, in weighting the HA expression can be appropriately distinguished form other expressions. In the suggested algorithm is expression is appropriately distinguished (100% recognition). After that, the SU expression has the little mixture with other expressions. In our algorithm, this issue is appropriately identified and the 98% recognition shows this issue. The SA expression is mixed with other expressions such as fear and hatred. In addition, the AM expression is more mixed with DI, but is mistaken with the FE expression in our algorithm. In addition, the DI expression is more mixed with expressions AN, FE, and SA. In our algorithm it is mistaken with FE and SA. The final expression FE raises the highest difference in ideas and a lot of interferences and it is mixed with DI and SU and with less mixture with AN and SA expressions.

It can be concluded that our algorithm the HA expression is exactly like other experts, have worked appropriately. In the SU expression, like most of experts have worked appropriately in facial expression recognition in 98% of cases and only had 2% of errors in the FE expression. With comparing expression and confusion matrix, our algorithm in the state CM3 can show that in cases when our algorithm mistakes one expression with another, the experts have given it high scores. This means that our algorithm has worked appropriately in mixed facial expressions, while in cases that it has had errors, they are not errors in fact. High scores by the experts can be that expression recognized by our algorithm.

7. Conclusion

Facial expressions recognition can be conducted with different methods. Form among the most important characteristics in most research, Gabor feature and LBP were used in the present study and investigated by M1 and M2 experiments. It was observed that they have proper accuracy in facial expression recognition. For improving the recognition accuracy, Gabor feature and LBP were employed in an integrated way and by achieving the accuracy of about 90% (similar to the mentioned resource) for the JAFFE, it was observed that the use of those two features can have high effectiveness on facial expression recognition. Then, by operationalizing the suggested method, the 9 part partitioning of images and local weighting using entropy method were used. In non-fuzzy method, the improvement was achieved up to 4% and in fuzzy method up to 6% higher than the previous experiments. The best results was with 96% of recognition accuracy. Regarding the previous studies, it was considered as appropriate accuracy.

Suggestions

In the present study, several issues were faced and some of the cases which can be effective on facial expression recognition are suggested as follows:

• Using partitioning with a number of sectors (in the present study 9 sector partitioning of images is used. This rate was selected with the suggestion of previous studies).

• The use of methods such as PCA and LDA to reduce features for improving the time of recognition

• Using the classifiers such as SVM, neural networks, and evolutionary algorithms.

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