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Smile Detection using Convolutional Neural Network and Fuzzy Logic

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Face recognition and identification of specific object is one of the key research areas for assorted domains including forensic applications whereby the suspicious persons or objects can be identified using their live features, behavior and traits. There are many segments in the human face which can be trained and further analyzed for the recognition in forensic applications. These objects are lips, forehead, cheeks, chin and many others which overall make the human smile and moves ahead to the face smile detection. In other areas of research, the work on hairstyle can be done but these can be manipulated, therefore the work on face smile detection is very prominent. In this research work, the deep learning based approach of Convolutional Neural Network (CNN) with the fuzzy logic is presented so that the higher degree of accuracy in the face smile can be done.

Keywords: deep learning, face smile detection, face smile recognition, convolutional neural network, face recognition using CNN, fuzzy logic

1. INTRODUCTION

Human Face Recognition is one of the major areas of research whereby the human faces and their inherent characteristics are fetched and trained so that the greater values in the accuracy level can be achieved [1]. The human face detection is directly associated with the other traits including face smile and emotions detection for achieving the greater dimensions of the human face. Following are the key techniques which are used for the face recognition in integration of multiple aspects.

- Traditional: In this type of approach using Traditional Features, the human face features from eye, skin, face, hairstyle *etc.* are extracted and trained in the model of training so that the further predictions and recognition can be done. The key approaches are PCA [2, 3], LDA [4], EBG [5, 6] and fisher-face approach [7, 8].
- 3-Dimensional Approach: The approach of 3D sensors is used in this dimension where by the metric geometry is followed to achieve the greater values in the accuracy and performance in the face recognition [7-10].
- Skin Texture Analysis: The visual aspects of the skin and face based analysis is done with the evaluation of mathematical space [11-13].

Thermal Imaging: The assorted types of cameras and imaging techniques are used for the face analysis and key features extraction [14, 15]. Following are the key applications of human face recognition for social as well as government segments [16-18].

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- Face ID
- Open Id for Government Records
- Criminal Recognition
- Security Applications
- Public Secured Places

Fig. 1. Face recognition system.

The face recognition systems can operate basically in two modes, see Fig. 1. Affirmation or approval of a facial picture: it in a general sense differentiates the data facial picture and the facial picture related to the customer which is requiring the confirmation. It is basically a 1×1 examination [19, 20].

Conspicuous confirmation or facial affirmation [21, 22]: it on a very basic level differentiation the information facial picture and each and every facial picture from a dataset with the arrangement to find the customer that facilitates that go up against. It is on a very basic level a 1×N connection [23].

There are different types of face recognition algorithms, for example:

Speed Up Robust Features (SURF) [24-26] makes use of integer approximation with the applications on real time images. It is huge faster than the traditional SIFT based approach.

Scale Invariant Feature Transform (SIFT) [27-29] integrates the usage of storing the key points in the database and further training for the prediction. The key stages in this approach includes scale invariant features, cluster identification, indexing and model verification.

Fisherfaces [30-33] is another approach and having the algorithm for the face recognition with the face smile detection with the computation of inverses in the points extraction phase. Local Binary Patterns Histograms (LBPH) [34-37] integrates the use of visual descriptor with the examination of cells after division into multiple segments. In addition, the normalization of the histogram is done so that the further analysis can be done with greater accuracy.

Eigenfaces [38, 39] makes use of PCA based approach and can be further integrated with other similar techniques. It is having the name from the eigenvectors. The evaluation of eigenvectors and matrix is done in this phase.

In case of effectiveness oriented face recognition, the key features in dynamic format from multiple angles of face are extracted [40-43]. In addition, the different orientations of the face are extracted from 360 degrees perspectives so that the overall evaluation of the face can be done, as in Eq. (1) [44-47].

$$C_m = \begin{cases} 1, & \sum_{i=0}^{I_m-1} F_{m,i} > \theta_m \\ 0, & \text{otherwise} \end{cases}$$
$$F_{m,i} = \begin{cases} \alpha_{m,i}, & \text{if } f_{m,i} > t_{m,i} \\ \beta_{m,i}, & \text{otherwise} \end{cases} \quad (1)$$

The presented equation and mathematical model is widely associated for the face recognition and in addition can be used for analysis of face smile [48-51]. The presented outcome gives the view of the different points in the features of human face which are quite important and paramount to study the multiple perspectives of the human face and smile as shown in Fig. 2.

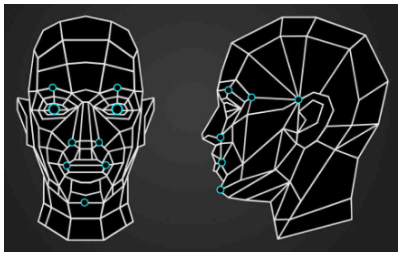


Fig. 2. Dynamic features in human face.

The face smile detection approach makes use of different phases including the face tracking with live features extraction. In addition, the alignment of the face emotions is done with the extraction of key points from lips and eye. The matching of features is done with the trained model for the prediction and analysis with the recognition percentage as shown in Fig. 3.

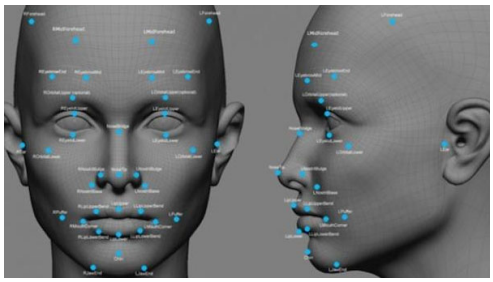


Fig. 3. Key points in face smile or emotions in human face.

2. DEEP LEARNING FOR SMILE DETECTION

Deep Learning [52-54] is one of the prime research areas in which the accuracy to 100% can be achieved without error factor. The deep learning makes use of Convolu-

tional neural networks in which each neuron and hidden layer is associated with the separate high performance algorithmic approach for the accuracy and minimum error factor.

3. STEPS OF THE PROPOSED APPROACH

3.1 Extraction of Parameters and Key Features

In this step, the orientation and dimensions of the digital image of face is analyzed including Radius, Neighboring Pixels, Grid X and Grid Y so that the multiple aspects of the images can be extracted.

3.2 Training of Algorithmic Model

The training process makes use of the key pixel positions and the intensity values with the required factors of the human face so that the actual impressions of face can be analyzed as shown in Figs. 4 and 5.

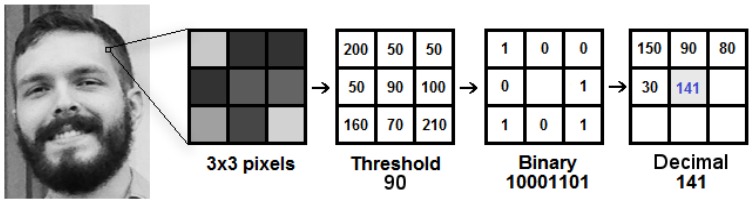
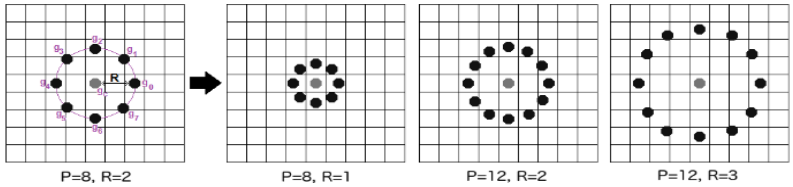


Fig. 4. Threshold and binary analysis.

3.3 Applying the Approach with Smile Detection:



(a) (b) (c) (d)

Fig. 5. Evaluation of key points and orientation.

3.4 Extraction of the Histograms

The histograms of the image with the smile operations and perspectives are fetched so that the deep and cavernous analysis of the smile for training can be done as illustrated in Fig. 6.

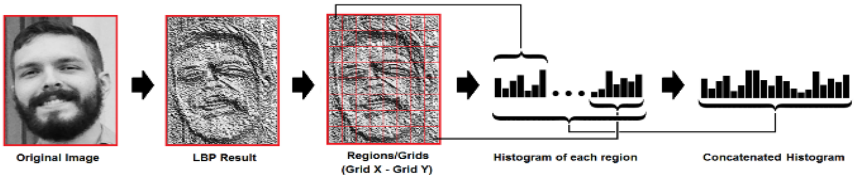


Fig. 6. Extraction and plotting of histogram.

4. PERFORMING CNN WITH FUZZY

The Convolutional neural networks with the fuzzy are integrated so that the accuracy and performance in the analytics phase can be done with the objective function as in Eq. (2).

$$D = \sqrt{\sum_{i=1}^{n} (hist1_i - hist2_i)^2} \tag{2}$$

In addition, Figs. 7 and 8 illustrate the accuracy level and the percentage can be extracted with the level of matching with the image in the face smile.

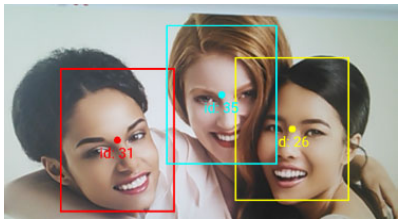


Fig. 7. Prediction with the accuracy and identification.

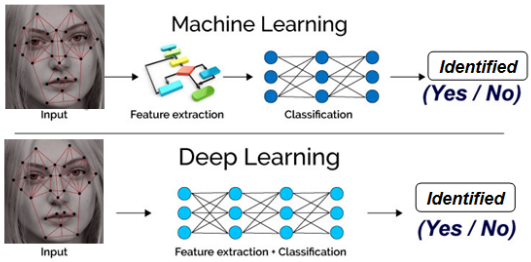


Fig. 8. Key demarcation points in the deep learning and machine learning.

In case of machine learning and deep learning based approach, there is major demarcation. In the case of CNN and fuzzy based deep learning, there is no need to explicitly extract the features. The deep learning integrated CNN automatically extracts the features so that the overall prediction will be more accurate with minimum level of error factor [55-58] as shown in Fig. 9.

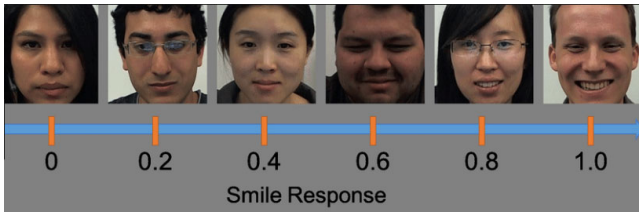


Fig. 9. Face analysis with smile response.

In addition, the smile response can be evaluated with the degree of matching with the emotions or sentiments of the person under evaluation [59-62]. The evaluation factors can be easily predicted with the analysis of the smile with the integration of higher degree of accuracy in the CNN integrated fuzzy approach.

5. CONCLUSION

Face smile detection is one of the prime areas of research in the segment of biometric applications in which the human face is trained and further analyzed for the assorted and diversified applications. The human face is having many emotions while the instances of smiling state and these traits are identified and trained in the modeling and predictions of the human being. This process can be widely used by the forensic teams and law enforcement agencies so that the presented outcome can be performance and accuracy aware.

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