ADABOOSTING BASED SMILE DETECTION IN COLOUR IMAGES

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Abstract

In this paper, a face detection method is presented for face images captured in the real world. Face detection is a difficult task in image analysis, which has more applications. The existing methods for face detection can be divided into image based methods and feature based methods. We present a pixel difference based technique for smile detection in the grayscale images of faces. We have developed an intermediate system, using a boosting algorithm to train a classifier which is capable of processing images rapidly while having high detection rates. The main idea in the building of the detector is a learning algorithm based on boosting: AdaBoost. AdaBoost is an aggressive learning algorithm which produces a set of classifiers by choosing visual features from the set of weak classifiers based on pixel difference. These weak classifiers act as a strong classifier in our implementation. This method achieves similar accuracy as compared with existing techniques. The 85% accuracy is achieved for 20 pairs of pixel value and 88% accuracy for 100 pairs of pixel value selected. We also found the Gabor-feature based accuracy using 350 pairs of pixel values.

Key Words: Smile detection, AdaBoost, feature selection, Gabor-features.

1. Introduction

In this paper, a face detection approach is presented. Face detection is an essential application of visual object detection and it is one of the main components of facial analysis and understanding with face localization and face recognition. Face detection is utilized in various applications such as biometric, photography, marketing, gaming, people tagging on Facebook and so on. The goal of face detection is to detect human faces in videos, real-time captured images and in various authentication systems.

In the past several years, lots of methods have been proposed and developed with different objectives to solve in different domains. We will make a global overview of the main of them and then focused on the efficient detector for processing images quickly and achieves higher image detection rates. The AdaBoost based detection technique is utilized in this paper, the response of simple Haar-based features used by Viola and Jones [1]. The Viola's algorithm framework for detecting face is utilized in various applications ranging from object detection to machine learning. Over the period this algorithm is applied in many areas such as machine learning, object detection, etc.

In this paper, we mainly focused on the detection of smile in the face images captured from cameras in actual world scenarios. We have used the standard image data set used in [2], the same has been shown in Figure 1. We present an efficient technique to detect a

smile, a simple feature is selected from the grayscale face image is the pixel difference in terms of its intensity. AdaBoost is utilized to select and combine the classifiers. The weak classifiers are chosen based on the pixel difference of intensity for smile detection works as strong classifier. This method achieves similar accuracy as compared with existing techniques. The 85% accuracy is achieved for 20 pairs of pixel value and 88% accuracy for 100 pairs of selected pixel value. We also computed the Gabor-feature based accuracy, using 350 pairs of pixel values.

Fig. 1 : Example of real life face images from GENKI4K [3] data set.

The remainder of this paper is organized as follows. In Section II, we highlight the literature review based on smile detection techniques. The proposed approach is demonstrated in Section III. Section IV illustrates in detail the experimentation and discussion on obtaining results. Finally, we conclude the paper in Section V.

2. Related Work

Various researchers are working intensively in the area of feature extraction and detection such as facial features or emotions. There are several feature extraction and detection techniques are found in the literature such as PCA [4], SVM [5, 6], AdaBoost [7], KNN [8], etc. A Viola [1] algorithm using AdaBoost and Haar-like features technique for robust face detection has been proposed in [9]. This technique is capable of detecting the faces four times faster as compared to [1]. A classifier based approach for fast face detection is presented in [10]. The authors, proposed the new AdaBoost based algorithm for the detection of face.

The frontal faces, locating facial features for high and low resolution images have to detect using AdaBoost approach is illustrated in [11]. The accuracy and reliability of detecting facial features are significantly better. The AdaBoost is widely utilized for training and to improve accuracy for learning algorithm. AdaBoost with SVM (Support Vector Machine) based face detection technique is presented in [12]. This technique demonstrates the better performance on imbalance classification problems.

A robust, accurate and real-time smile detection system is proposed in [13], the obtained results have been compared with smile shutter function suggested by SONY DSC T300. This system achieves better performance with compared device. In [14], a practical smile detection technique for the current machine learning system is developed for real-time system. The different characteristics have been identified, such as a training data set, image registration, feature representation, and machine learning algorithms. A new data set, GENKI is also presented for different real-world imaging conditions.

In the recent year, different methods for smile detection have been proposed. The Edge Orientation Histograms (EOH) feature based smile detection approach is presented in [15]. This system is designed to correctly differentiate between broad smile and thin smile and achieved the accuracy of 87.8%. The KNN algorithm based smile detection in embedded system on Raspberry Pi is proposed in [16]. This proposed system achieves the accuracy of 66.6% for smile detection. The latest implementation for

detecting fake smile on face images using SVM is demonstrated in [17]. The characteristic features for fake smile detection selection are negative emotions, uncomfortable feelings, etc. In [18], automatic facial features such as head positioning, facial feature tracking, etc. based on unsupervised learning technique has been discussed for robust software package implementation for facial feature recognition. The LDN (Local Directional Number Pattern) and LTrP (Local Tetra Pattern) based technique for the recognition of human facial expression has been implemented in [19]. These techniques are trained using SVM, and classifies the various facial expressions such as sad, smile, etc. This proposed implementation is only utilized for various facial expressions to recognize. A CNN (Convolution Networks) based high level feature extraction is proposed by the authors [20]. The smile is the main feature focused and recognized. The 21% of error rate has been reduced by this method for GENKI dataset. A comparative study based on the smile detection using various methods has been studied in [21]. This comparative study aims to detect the smile automatically.

3. Ada Boost and boosting pixel difference

In facial feature analysis, the main objective is to extract effective features such mouth corners, eyes, nose, eyebrows and geometric points, etc. The accurate extraction of these features is essential for face expression analysis, but it is trivial to find these features in real-time environment. Moreover, for practical applications, the computation time is required is substantially less. This is due to limited computing resources, hence is necessary that the selected features can be calculated with ease. The two pixel values as a feature is introduced in [22], [23], the highest accuracy is obtained by using the relationship between two pixel values. The pixel value comparison required for 20×20 image size is $2 \times 5 \times (20 \times 20)(20 \times 20 - 1)$ or 1596000 (for more detail see [23]).

In this paper, two pixels difference relationship as image feature is examined. But, we only utilize the intensity of pixels as simple feature. We need not require all these comparison, only intensity difference comparison is useful. Hence, the comparison is reduced to ten times for an image size of 20×20 as $(20 \times 20)(20 \times 20 - 1)$ or 159600 extracted features. We further reduced this feature by half by selecting the upper diagonal part of the pixel value pairs as the required features. With this large number of extracted features, it is necessary to minimize the features to compute new face image. The reduction of these

features can be achieved by AdaBoost [24] algorithm. The Algorithm 1 shows the detail working of AdaBoost. AdaBoost provides the feature selection and training of classifier needed for the selection desired classifier, weighted error minimization. In this paper, we have chosen the weak classifier based on the pixel intensity values. The weak classifier $h_j(x)$, feature f_j , threshold θ_j , p_j the parity, indicate the sign of the direction of the inequality as;

$$h_j(x) = \begin{cases} 1, & \text{if } (p_j f_j(x) \leq p_j \theta_j) \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

Algorithm 1: AdaBoost

1. Input: Training data set (x, y_i) , $i \leftarrow 1$ to N with positive ($y_i = 1$) and negative ($y_i = 0$) data set.

2. Initialization: weights $\omega_{1,i} = \frac{1}{2m}, \frac{1}{2l}$ with m

negative and l positive data sets.

3. For $t \leftarrow 1$ to T

3.1 Normalize all weights; $\omega_{ti} \leftarrow \frac{\omega_{ti}}{\sum_{j=1}^n \omega_{ti}}$

3.2 For each feature f_j train classifier h_j with error; $\varepsilon_j = \sum_i \omega_{ti} |h_j(x_i) - y_i|$

3.3 Choose h_t with lowest error ε_t

3.4 Update weights; $\omega_{t+1,i} = \omega_{t,i} \beta_t^{1-e_i}$

where $e_i = 0$ if x_i is correctly classified and $e_i = 1$ otherwise and $\beta_t = \frac{\varepsilon_t}{1-\varepsilon_t}$

4. Final strong classifier;

$$h(x) = \begin{cases} 1 & \sum_{t=1}^T \alpha_t h_t(x) \geq 0.5 \sum_{t=1}^T \alpha_t \\ 0 & \text{otherwise} \end{cases}$$

$$\alpha_t = \log\left(\frac{1}{\beta_t}\right)$$

4. Experimentation

For experimentation and analysis, we have selected the different methodology for smile detection such as AdaBoost with pixel difference, Gabor features and LBP features. Table 1 shows the features and dimension obtained for the detection of face smile. The Gabor features are chosen as suggested in [25], due to better performance for smile detection (for more detail see [26]). The other method for feature selection, we selected as LBP. LBP has also shown the

convincing performance for face feature selection in the literature such as [27].

We applied all these methods for the detection of face smile on the grayscale images of faces. The results obtained are summarized in Table 1. The pixel difference methodology with AdaBoost gives best performance in terms of accuracy and less time consumed in the overall computation process. The same can be visualized from the Table 1. By selecting top 500 features, the pixel difference with AdaBoost achieved 89.75% of accuracy. After observation our approach achieved 85% accuracy for 20 pairs of pixel value and 88% accuracy for 100 pairs of pixel value and for Gabor-feature based method accuracy is found by using 350 pairs of pixel values.

Table 1
Comparison of different methodology of Smile Detection.

Methodology			Accuracy (%)
Feature	Dimension	Classifier	
Pixel Comparisons	500	AdaBoost	89.75 ± 0.52
Gabor	944	SVM	89.70 ± 0.73
LBP	23040	SVM	87.85 ± 0.57

Fig. 2 : Shows the relationship between the number of weak classifier and accuracy obtained by our method. The 85% accuracy is achieved for 20 pairs of pixel values and 88% accuracy for 100 pairs of pixel values.

Fig. 2 : Relationship between accuracy and number of weak classifiers.

Example 1: Output of AdaBoost pixel comparison:

Figures from Fig. 3 to Fig. 10 shows the outcome at different stages of smile detection from face image. Fig. 3 is the input face image for smile detection. The closed face image is found in Fig. 4 by applying image cropping. The image pre-processing applied and grayscale image is obtained in Fig. 5. Fig. 6 shows the normalized image for the further processing of images is obtained. At this point, the face image is ready to apply the proposed methodology for the detection of smile on face. Fig. 7 is the outcome after selection of features required for successive computation. The pixels of our interest are selected and the pixel intensity difference is computed. The pixels are further reduced by half and only the lower triangle of the image is considered for respective computation is shown in Fig. 9. Fig. 10 shows the final outcome of the overall computation of the proposed methodology.

Preprocessed Image

Fig. 5 : Preprocessed image.

Query Image

Fig. 3 : Input image to detect face smile.

Normalised Face Image

Fig. 6: Normalized face image.

Cropped Face Image

Fig. 4 : Cropped image of a face.

Fig. 7 : Desired features are selected.

Fig. 8 : The Intensity pixel difference is computed.

Fig. 9 : Half the pixels are chosen as the lower triangle of the image.

Fig. 10 : Final outcome of the input image for smile detection.

5. Conclusion

Smile detection in face images is an attractive problem has many applications in real-time. The computational capability is limited by available resources, it is necessary to extract the desired features which can be efficiently computed to produce a desirable outcome. In this paper, a simple feature as pixel differences for intensity of grayscale image is selected. AdaBoost is an aggressive learning algorithm which produces a set of classifiers by

choosing visual features from the set of weak classifiers based on pixel difference. These weak classifiers act as a strong classifier in our implementation. This method achieves similar accuracy as compared with existing techniques. The 85% accuracy is achieved for 20 pairs of pixel value and 88% accuracy for 100 pairs of pixel value selected. We also found the Gabor-feature based accuracy using 350 pairs of pixel values.

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