A Novel Approach For Smile Detection Combining LBP And PCA

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1 Introduction

In this work we propose a novel approach for the detection of smiles in video streams. The distinctive configuration of a smile may pose less problems than other, at times subtle, expressions. On the other hand, smiles can still be very useful as a measure of happiness, enjoyment or even approval. Here, a method is presented that combines the approaches based on Local Binary Patterns (LBP) and Principal Components Analysis (PCA). The results briefly commented in this paper, present interesting possibilities of application in the context of facial expression recognition.

2 Representation

For representation purposes, it is important to simplify the amount of data to process, while keeping the required information for the addressed task. Two state of the art well known approaches are used in this paper with that aim: Local Binary Pattern (LBP) and Principal Component Analysis (PCA).

The Local Binary Pattern (LBP) is an image descriptor commonly used for classification and retrieval. Introduced by Ojala et al. [2] for texture classification, they are characterized by invariance to monotonic changes in illumination and low processing cost.

Given a pixel, see Figure 1-a, the LBP operator thresholds the circular neighborhood within a distance by the pixel gray value, and labels the center pixel considering the result as a binary pattern, see Figure 1-b.

Rotation invariance is achieved in the LBP based representation considering the local binary pattern as circular. The experience achieved in [2] suggested that just a particular subset of local binary patterns is typically present in most of the pixels contained in real images. They refer to these patterns as uniform. Uniform patterns are characterized by the fact that they contain, at most, two bitwise transitions from 0 to 1 or viceversa. In the experiments carried out by Ojala et al. [2] with texture images, uniform patterns account for a bit less than 90% of all patterns when using the 3x3 neighborhood.

Using LBP as a preprocessing method has the effect of emphasizing edges and noise. To reduce the noise influence, Qian Tao et al. [5] recently proposed a

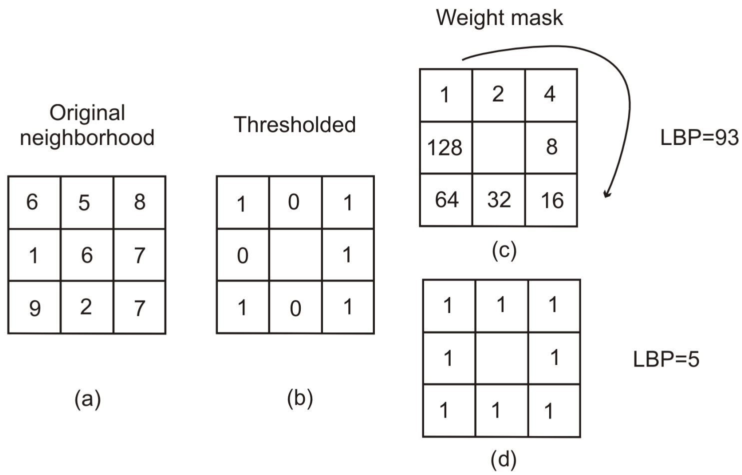

Fig. 1. The basic version of the Local Binary Pattern computation (c) and the Simplified LBP codification (d).

modification of the LBP approach. Instead of weighting the neighbors differently, their weights are all the same, obtaining the so called Simplified LBPs, see Figure 1-d. Their approach has shown some benefits applied to facial verification, due to the fact that by simplifying the weights, the image becomes more robust to illumination changes, having a maximum of nine different values per pixel. The total number of local patterns are largely reduced so the image has a more constrained value domain.

In the novel approach proposed at Section 3, two different representation approaches will be analyzed, i.e. using the histogram based approach, but also using Uniform LBP and Simplified LBP as a preprocessing step.

On the other hand, a classical technique applied for face representation to avoid the consequent processing overload problem is Principal Components Analysis (PCA) decomposition [4]. PCA decomposition is a method that reduces data dimensionality, without a significant loss of information, by performing a covariance analysis between factors. As such, it is suitable for highly dimensional data sets, such as face images. A normalized image of the target object, i.e. a face, is projected in the PCA space. The appearance of the different individuals is then represented in a space of lower dimensionality by means of a number of those resulting coefficients, v_i.

3 The Approach

The approach considered in this work has been developed after carrying out an extensive study with a large dataset of images with uncontrolled illumination,

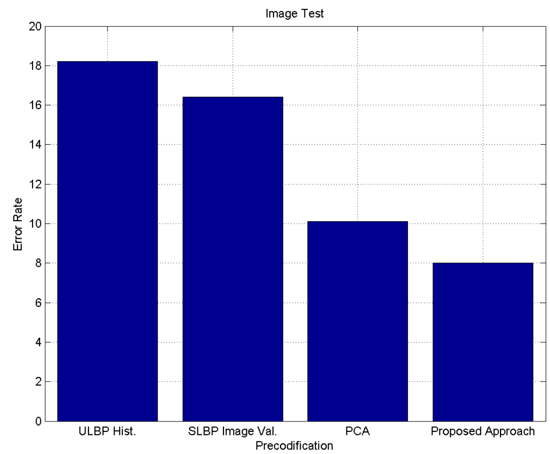

Fig. 2. Results of processing images with the selected approaches

i.e. under different lighting conditions. The approach combines different techniques achieving the lowest error rate and the most robust data representation, coping also with situations where drastic illumination changes occur. Thus, for representation purposes, the novel function is composed by the combination of the following techniques:

- A PCA space obtained from the original gray images.
- A concatenation of histograms based on the resulting Uniform LBP image.
- An image values space obtained from the mouth region of the resulting Simplified LBP image.

Where the error rate reported for each single approach were 10.1%, 18.2% and 16.4% respectively. The combination function proposed in our novel experimental approach is:

$$Decision_i = \sum (ULBP\_frame_k + SLBP\_frame_k + Grayscale\_frame_k) \tag{1}$$

Where XXX_frame_k is the decision taken by the approach XXX for the k frame. XXX is a variable that could stand for ULBP, SLBP or Grayscale previously mentioned approaches.

Each classifier has two possible outputs: +1 for smiling face detection and -1 for no smiling face detection. Therefore, if the previously explained equation returns a value greater than 0 for a frame, then, this frame is tagged as smiling face, otherwise, is tagged as non smiling face.

4 Experiments

The dataset of images used for the experimental setup is separated into two classes: smiling and not smiling. The dataset has been previously annotated by humans who labeled each normalized image of 59×65 pixels. The first set contains 2421 images of different smiling faces, while the second set contains 3360 non smiling faces.

The average results achieved after selecting randomly ten times half of the dataset for training and the other half for testing with this novel approach is over a **8%** of error rate. The rate is achieved even when the lighting conditions are heterogeneous in the dataset. This is achieved thanks to the robustness of the LBP representation for different lighting conditions.

A 8% of error rate shows a notable improvement, where the false positive rate is over a 4% and the false negative rate over a 11%.

5 Conclusions

This paper summarizes a study carried out on a novel approach for the smile detection based on the combination of different techniques.

As it is observed, the proposed combined approach of different approaches reported lower error rates than each one of the individual approaches. This novel approach not only has achieved a lower error rate than each individual approach alone, but it makes use of the benefits of each approach, such as robust behaviour for changing lighting conditions.

Our next objective is to apply this approach on video streams under different lighting conditions and to improve the error rate by the application of a weighted Temporal Window approach. Also, it is important to perform a more exhaustive study to determine the optimal combination fucntion, as well as, on the analysis of the most significant parts of the facial image for this problem for the input to obtain a more accurate preprocessed SLBP or ULBP image.

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