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Face Detection and Recognition using Local Binary Patterns

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ABSTRACT: Now a days, applications in the field of surveillance, banking and multimedia equipment are becoming more important, but since each application related to face analysis demands different requirements on the analysis process, almost all algorithms and approaches for face analysis are application dependent and a standardization or generalization is quite difficult. For that reason and since many key problems are still not completely solved, the face analysis research community is still trying to cope with face detection and recognition challenges. Local Binary Patterns were first used in order to describe ordinary textures[1] and, since a face can be seen as a composition of micro textures depending on the local situation, it is also useful for face description. The LBP descriptor consists of a global texture and a local texture representation calculated by dividing the image into blocks and computing the texture histogram for each one. The global is used for discriminating the most non-face objects (blocks), whereas the second provides specific and detailed face information which can be used not only to select faces, but also to provide face information for recognition[2].The results will be concatenated in a general descriptor vector, that will be later used to feed an adequate classifier or discriminative scheme to decide the face likeness of the input image or the identity of the input face in case of face recognition.

KEYWORDS*:* Emotion classification , LBP, Texture Feature, face detection, PCA.

I. INTRODUCTION

Face detection and recognition are playing a very important role in our current society, due to their use for a wide range of applications such as surveillance, banking and multimedia[3] equipment as cameras and video game consoles to name just a few. Most new digital cameras have a face detection option for focusing faces automatically. Some companies have even gone further, like a well-known brand, which has just released a new functionality not only for detecting faces but also for detecting smiles by analyzing “happiness” using facial features like mouth, eye lines or lip separation, providing a new “smile shutter” feature which will only take pictures if persons smile. In addition, most consumer electronic devices such as mobile phones, laptops, video game consoles and even televisions include a small camera enabling a wide range of image processing functionalities including face detection and recognition applications. For instance a renowned TV manufacturer has built-in a camera to some of their television series to make a new feature called Intelligent Presence Sensor possible. The users’ presence is perceived[4] by detecting faces, motion, position and even age, in the area in front of the television and after a certain time with no audience, the set turns off automatically, thus saving both energy and TV life. On the other hand, other demanding applications for face detection and recognition are in the field of automatic video data indexing to cope with the increase of digital data storage. For example, to assist in the indexing of huge television contents databases by automatically labeling all videos containing the presence of a given individual. In a similar way, face detection and recognition techniques are helpful for Web Search Engines or consumers’ picture organizing applications in order to perform automatic face image searching and tagging. For instance, Google's Picasa digital image organizer has a built-in face recognition[5] system that can associate faces with people, so that queries can be run on pictures to return all images with a specific group of people together. Another example is iPhoto, a photo organizer distributed with iLife that uses face detection to identify faces of people in photos and face recognition to match faces that look like the same person. After four decades of research and with today’s wide range of applications and new possibilities, researchers are still trying to find the algorithm that best works in different illuminations, environments, over time and with minimum error.

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II. FACE DETECTION AND RECOGNITION

In most cases, these research areas presume that faces in an image or video sequence have been already identified and localized. Therefore, in order to build a fully automated system a robust and efficient face detection method is required, being an essential step for having success in any face processing application. Face detection is a specific case of object-class detection, which main task is to find the position and size of objects in an image belonging to a given class. Face detection algorithms were firstly focused in the detection of frontal human faces, but nowadays[6] they attempt to be more general trying to solve face multi-view detection: in-plane rotation and out-of-plane rotation. However, face detection is still a very difficult challenge due to the high variability in size, shape, color and texture of human faces. Generally, face detection algorithms implement face detection as a binary pattern classification task. That means, that given an input image, it is divided in blocks and each block is transformed into a feature. Features from class face and non face are used to train a certain classifier. Then given a new input image, the classifier will be able to decide if the sample is a face or not. Face detection methods can be classified in the following categories

Knowledge-based methods: these techniques are based in rules that codify human knowledge about the relationship between facial features.

Feature invariant techniques :(texture and multiple features): they consist of finding structural features that remain invariant regardless of pose variations and lighting condition.

Template matching methods (e.g. predefined templates and deformable templates): these approaches are based in the use of a standard face pattern that can be either manually predefined or parameterized by means of a function. Then, face detection consists of computing the correlations between the input image and the pattern.

Appearance-based methods (e.g. Neural Networks , Support VectorMachine , Hidden Markov Models): contrary to models searching techniques,appearancebased models or templates are generated training a collection of images containing the representative variations of face class.

Color-based methods: these techniques are based on the detection of pixels which have similar color to human skin. For this propose, different color spaces can be used etc.

AdaBoost face detector: the Adaptive Boosting) method consists of creating a strong face detector by forming an ensemble of weak classifiers for local contrast features found in specific positions of the face.

Video-based approaches (e.g. color-based, edge-based, feature-based, optical flow-based , template-based and Kalman filtering-based face tracking): this kind of face detectors exploits the temporal relationship between frames by integrating detection and tracking in a unified framework. Then, human faces are detected in the video sequence, instead of using a frame-by-frame detection.

III. LOCAL BINARY PATTERNS

The LBP originally appeared as a generic texture descriptor. The operator assigns a label to each pixel of an image by thresholding a 3x3 neighborhood[7] with the centre pixel value and considering the result as a binary number. In different publications, the circular 0 and 1 resulting values are read either clockwise or counter clockwise. In this research, the binary result will be obtained by reading the values clockwise, starting from the top left neighbor, as can be seen in the following figure.

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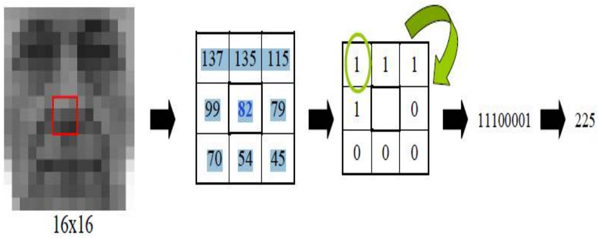

Fig. 1 LBP labeling: binary label is read clockwise starting from top left neighbour.

In order to treat textures at different scales, the LBP operator was extended to make use of neighborhoods at different sizes. Using circular neighbourhoods[9] and bilinear interpolation of the pixel values, any radius and number of samples in the neighborhood can be handled. Therefore, the following notation is defined:

(P, R) which means P sampling points on a circle of R radius. The following figure shows some examples of different sampling points and radius:

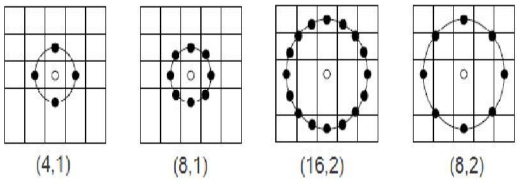

Fig. 2 LBP different sampling point and radius examples

In LBP(4,1) case, the reason why the four points selected correspond to vertical and horizontal ones, is that faces contain more horizontal and vertical edges than diagonal ones.When computing pixel operations taking into account NxN neighborhoods at the boundary of an image, a portion of the NxN mask is off the edge of the image. In such situations, different padding techniques are typically used such as zero-padding, repeating border elements or applying a mirror reflection to define the image boarders. Nevertheless, in LBP operator case, the critical boundary, defined by the radius R of the circular operation, is not solved by using a padding technique[8], instead of that, the operation is started at image pixel (R, R). The advantage is that the final LBP labels histogram will be not influenced by the borders, although the resulting LBP labels image size will be reduced to (Width-R)x(Height-R) pixels.

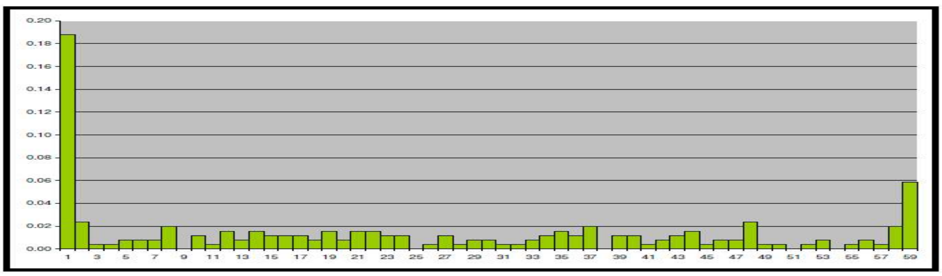

Fig.3 59-bin $LBP_{(8,1)}$histogram from a 16x16 Internet face image

Local Binary Patterns applied to FaceDetection:

The first step in face detection is preprocessing. The reason is to obtain pure facial images with normalized intensity, uniform size and shape. The steps involved in converting a image to a normalized pure facial image for feature extraction is detecting feature points, rotating to line up, locating and cropping the face region using a rectangle, according to the face model. Detecting faces in a single image involves four methods Knowledge based, Facial invariant, Template matching and Appearance based[10]. Feature extraction is a method in facial recognition. It involves several steps like dimensionality reduction, feature extraction and feature selection. Dimensionality reduction is an important task in pattern recognition system.

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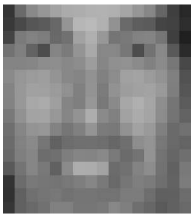
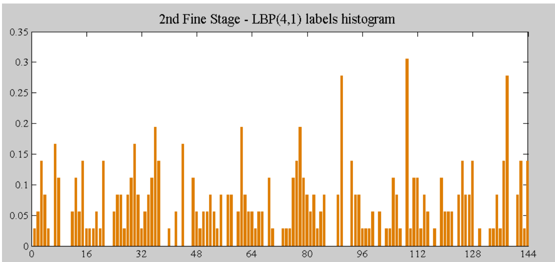
Facial Features Extraction: Feature value extraction subsystem is to extract 18 feature points from facial image, and calculate 16 feature values from those points. At first, from a color image image taken by CCD camera, the background is excluded and the facial image is extracted. Then the facial organs such as brows, eyes and mouth are extracted. After processing facial organs' image into binary image, feature points are extracted and feature values are calculated.



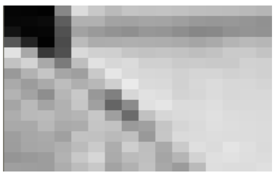
(a) Face sample

(b) 1st Stage LBP(8,1) labels image



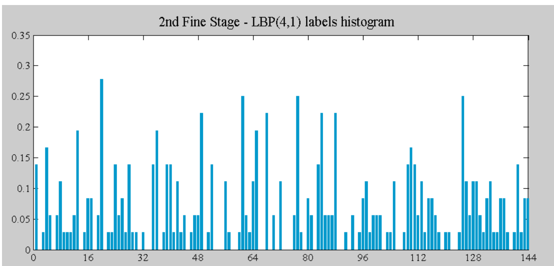
(c) 2nd Stage LBP(4,1) labels histogram

Fig.4 Face image - Labels histogram example



(a) Non-face sample

(b) 1st Stage LBP^2 (8,1) labels image



(c) 2nd Stage LBP(4,1) labels histogram

Fig. 5 Non-face image - Labels histogram example

IV. APPLICATIONS

As a very simple texture operator, the LBP is ideally suited for applications requiring fast feature extraction. Due to its simplicity and performance, many people have applied it to a number of different applications. These are outlined in the following sections.

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Industrial Visual Inspection:

Although many potential application areas for texture analysis exist in industry, only a limited number of successful exploitations have been reported. One of the major problems is the non-uniformness of real-world textures, which is caused by changes in orientation, illumination, scale, etc. In addition, the computational requirements of many proposed texture features are high. One of the first industrial applications of the LBP was metal surface inspection. Later, in a system in which a subset of the LBP codes was used in characterizing defects in automobile engine valves. They compared different feature extraction schemes in a segmentation process[11] needed for the analysis of laundry detergents. One of the most commonly reported applications of the LBP is wood inspection, with which the operator has been used with color measures. A common approach has been to use color and texture features with non-supervised clustering methods. Color and texture features, including the LBP, have been used in a demanding real-time parquet inspection problem. Paper inspection has been a successful application area with the LBP.

Image Retrieval:

A number of researchers have used LBP as part of their image retrieval systems. Lew presented a system called "Imagescape", which used distribution-based texture features[12] as texture models. These features included the LBP, LBP/C, and "Trigrams", which was a variant of the LBP calculated from an edge image. Also Berman and Shapiro have used LBP as a texture feature in their "Flexible Image Database System". Schaefer in turn applied the operator to JPEG-compressed images for image retrieval. He found that with compressed images, sub-sampling does not decrease indexing accuracy. LBP has also appeared as a texture feature in studies.

Scene Analysis:

Recent findings from human psychophysics, neurophysiology and computer vision provide evidence for a framework in which objects and scenes are represented as collections of viewpoint-specific features rather than 2D templates or 3D models. This approach has been utilized in recognizing real-world textures with the LBP. In these works, representative models for textures were found with feature self-organization[14]. It was shown that it is possible to learn a small subset of texture samples that can reliably work as representatives in classifying textures. Promising results were reported in classifying textures and in the segmentation of outdoor scene images.

Face Analysis :

Face analysis is among the most intriguing, and perhaps surprising, applications of the LBP. Here both shape and texture information is used in representing face images. The face area is first divided into small regions from which LBP histograms are extracted. The histograms are concatenated into a single, spatially enhanced feature histogram efficiently representing the face image. Experiments clearly show that the proposed method is superior to all the state-of-the art methods it was compared to (PCA, Bayesian Intra/extrapersonal Classifier and Elastic Bunch Graph Matching). The evaluation was performed with the FERET database, which includes different facial expressions, lighting and aging of the subjects. LBP as a powerful feature for face detection and recognition. The same facial representation is used in both tasks, which is seen as an important property: a unified feature space makes it possible to combine detection and recognition into one framework in which both tasks support each other. In xperiments, the LBP performed equally well or better than any reference method in face detection. In recognizing faces from low-resolution images, the LBP was found to be superior to the reference methods. The study indicates that LBP-based methodology can be used in recognizing facial expressions[13]. In experiments, LBP features combined with the linear programming classification technique yielded better results than other methods with the JAFFE database.

V. CONCLUSIONS

The LBP operator can be seen as a truly unifying approach to the traditionally divergent statistical and structural models of texture analysis. Texture is described in terms of micro-primitives and their statistical placement rules. Optionally, the primitives may be coupled with a complementary measure of local image contrast, which measures the strength of the primitives. The LBP[15] operator is relatively invariant with respect to changes in illumination and image rotation. It can even resist changes in texture scale. Still more work needs to be done to make the operator invariant against 3-D distortions, often present in natural scenes, for example. The promising results achieved in view based recognition and in detecting moving objects indicate that this problem can be solved with the LBP. Furthermore, the success in detecting and recognizing faces suggests that the LBP may be useful in many object recognition tasks that have not previously been considered texture analysis problems. Perhaps the most important property of the LBP operator in real-world applications is its tolerance against illumination changes. Equally important is its computational simplicity, which makes it possible to analyze images in challenging real time settings. To help researchers and application developers, C++ and Matlab implementations of the operator are provided free of charge.

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