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Face Recognition Using Low Light

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ABSTRACT

Face detection has been well studied for many years. One remaining challenge is to detect faces from low-light images. The brightness of the image captured under extremely low-light conditions could be very low and the contrast will be severely reduced. It is easy to confuse feature extraction and affects the performance of face detection. In this paper, we propose a single-stage low-light face detection method. First, we design an improved MSRCR method to increase the image quality under the condition of ensuring that the colors of the image are not distorted. It shows a better enhancement effect than other methods in the DARK FACE dataset, especially since the low-resolution face details are well preserved. There are several small, blurred, and partially occluded faces. To address this, the Pyramidbox algorithm is a very effective face detection algorithm. Moreover, we conduct multi-scale tests to further develop the performance of the model and integrated the results through the Soft-NMS method to obtain final results. Integrating these techniques, this paper has achieved high accuracy and obtained excellent results in the face detection task of the DARK FACE dataset.

I. INTRODUCTION

One of the most crucial problems in face recognitionpractice is the variations of light intensity in input imagesprocessed by FaReS (Face Recognition System). In sucha situation we have to deal with two types of complications inthe area of the face and its background. The first one is relatedto local shadows, while the second one is associated withso-called global shadows. Local shadows change the formof individual parts of the face (nose, mouth, and eyes) anddistort the boundaries of the face area. Global shadowssignificantly reduce the discrimination of various face areasagainst the general background and/or completely hide them.Such kinds of problems strongly influence the accuracy ofFaReS operation, thus this is the main reason for the lastinginterest of face recognition specialists [1-11]. Analysis ofthe literature leads to the observation, that the problem isstill unsolved in a satisfactory way. In this paper, we focus on methods involvingthe dimensionality reduction approach. The authors of [1] showthat to solve recognition tasks using the PCA andLDA, FILPs should be transformed into spectral featuresusing two-dimensional DCT (2DDCT). At the sameprocessing stage, the low-frequency spectral componentsare removed, as corresponding to „shadow" components. In[1] the authors proposed the following procedure involvingone-dimensional PCA and LDA.

II. RELATED WORK

Related Work The focus of this paper is to propose a face detection method for low-light images and it is closely related to two aspects: low-light image enhancement and face detection. Low-light image enhancement. Low-light image enhancement has always been an important means to improve image perception quality [20]. The common enhancement methods can be divided into two categories [37]: 1) imagerestoration based on physical models; 2) image enhancement based on image processing techniques. For the first category, by establishing and inverting the image degradation process to obtain the best estimate of the clear image [12, 31], and the second category directly improves contrast and highlights details by global or local pixel processing, regardless of the cause of color cast and image degradation [15]. Many efficient solutions are frequently designed based on the retinex theory [17]. It assumes an image as a combination of a reflectance map that reflects the physical characteristic of scene objects and a spatially smooth illumination map. Based on this theory, algorithms were designed to focus on resolving the ambiguity between illumination and reflectance by imposing certain priors on a variational model based on empirical observations

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[7, 8, 11, 19]. There are many algorithms based on retinex theory such as single-scale retinex (SSR), multi-scale retinex (MSR), and multi-scale retinex with color restoration (MSRCR) [15]. In this paper, we constantly adjust and improve the MSRCR algorithm to find a low-light image enhancement method that best matches the DARK FACE dataset, which not only improves the perceived quality of the original image but also ensures that the subsequent face detection algorithm can exert more stable performances

Characteristics of images used in experiments

The literature review shows that most of the reportedexperiments in the area of facial portrait recognition in the
presence of variable lighting conditions are conducted onthe Yale database [12] as it seems to be a de facto standard inthe scientific community. Complete Yale database includesoriginal Yale B images and its extension called Yale B+[12]. In experiments we used 2452 out of 2470 images fromYale B and Yale B+ sets, containing the central part of the facearea of 38 subjects (18 images were omitted since theycannot be read from files published on web site [12]). Allimages are stored in grayscale in matrices of 192×168pixels, divided into 6 sets, labeled Subset 0 Subset 5,respectively. Images in Subset 0 have no blinks, and shadowsand features ambient lighting. Images in Subset 1 Subset 5were obtained by modeling the spatial movement of a lightsource, hence containing various variants of shadows –flashes (Subset 1 and Subset 2), local shadows (Subset 3), and lateral shadows (Subset 4 and Subset 5), as well asglobal shadows (Subset 5). The most difficult for recognitionare images from Subset 3 Subset 5. Figure 1 presentsexample images from these sets.

Fig.1. Selected images from the Yale database

Face image preprocessing

It is obvious that without brightness equalization of testimages the recognition rate will be very low. As shown in[1-9], the methods of brightness enhancement (shown in Fig.2) can employ gamma correction or perform a logarithmon pixel intensities. However, this procedure must respectsuch parameters of the input image as mean value, localbrightness, boundaries of shadows, as well as contrast.Unfortunately, such a procedure may have a negativeinfluence on recognition accuracy. Figure 2 presentsoriginal images influenced by different lighting conditionstogether with results of applying one of two enhancingprocedures: gamma correction (G) and brightness logarithm(Log). Observed distortions (like not removed shadows,introduced new bright spots, loss of contrast, noise) arevisible in resulted images – especially whencompared to original images. Even though the boundariesof different parts of the face can be easily detected, theanthropometric parameters of faces may be successfully explored. It is also visible that gamma correction andlogarithmic transformation of the original image unveil differentparts of the face, originally hidden in the shadow, leading to theimprovement of the recognition rate.Both procedures can be easily described using thefollowing formulas. Letme be an image of sizeM×N pixels, containing values from the range<0, 255>. The gammacorrection procedure applied for changing the brightness ofeach pixelof the image I am implemented as follows:

(3) $i_G(m,n) = i(m,n)^\gamma, \ \forall\, m=1,\dots,M$ and $n=1,\dots,N$.

where: iG(m, n) – pixel after correction; γ-coefficient of power transform, γ<<l
The logarithmic transformation consists of two steps. In the firststep all zero values in the image matrix are replaced byones, so that:

(4) $i(m,n) = i(m,n)+1, \ \forall\, i(m,n) \equiv 0.$

In the next step the logarithm is calculated:

(5) $i_L(m,n) = \log(i(m,n)), \ \forall\, m=1,\dots,M$ and $n=1,\dots,N$.

whereiL(m,n)– a new brightness of a pixel.

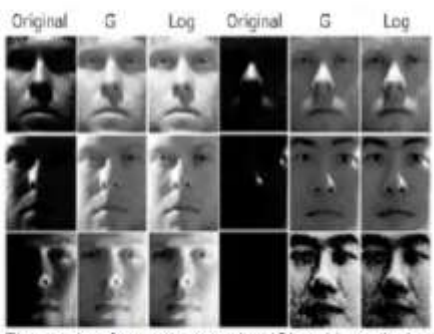

Fig.2. The results of gamma correction (G) and intensity logarithm (Log) applied on original images

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Practical implementation of 2D DCT

We can define the 2DDCT in a matrix form as follows [13]:

Y=F1I F2,

whereI – the original image of sizeM×N;Y – transformation result;F1andF2– projection matrices of sized1×M andN×d2, where:

$$(7)\quad f(d_1,m)=\begin{cases} 1/\sqrt{M}, & \text{if } d_1=0,\\ \sqrt{\frac{2}{M}}\cos\frac{\pi(2m+1)d_1}{2M}, & \text{if } d_1=1,\dots,D_1-1,\end{cases} \quad \forall m=0,1,\dots,M-1.$$

$$(8)\quad f(n,d_2)=\begin{cases} 1/\sqrt{N}, & \text{if } d_2=0,\\ \sqrt{\frac{2}{N}}\cos\frac{\pi(2n+1)d_2}{2N}, & \text{if } d_2=1,\dots,D_2,\end{cases} \quad \forall n=0,1,\dots,N-1$$

One important spectrum feature should be noted. Two-dimensional DCT allows obtaining spatial-spectral features, invariant against mirror-symmetric modification of aheadto the left and/or right in the original image plane. This fact is proved by a result presented in Fig. 3. It shows twoimages from Yale B set, featuring mirror symmetry ofthe lighting source. Original spectra correspond to regular 203(signed) 2DDCT of both images (one is represented by dots while the other with solid lines). Absolute values of 2DDCTspectra for these images are identical. Thus, the absolutevalue of the 2DDCT spectrum is invariant against the mirror-symmetric transformation of face images. Please note that in practical applications of face recognition above-mentioned fact of invariance can also result in better face recognition in case of head rotation around the vertical axis, and also in case of not perfect mirror-symmetry of lightingsource.

Processing algorithm.

It is essential to know that computer algorithms have the most significant role in digital image processing. Developers have been using and implementing multiple algorithms to solve various tasks, which include digital image detection, image analysis, image reconstruction, image restoration, image enhancement, image data compression, spectral image estimation, and image estimation. Sometimes, the algorithms can be straight off the book or a more customized amalgamated version of several algorithm functions.

Types of Image Processing Algorithms

Some of the conventional image processing algorithms are as follows:

Contrast Enhancement algorithm: The color enhancement algorithm is further subdivided into -

- Histogram equalization algorithm: Using the histogram to improve image contrast
- Adaptive histogram equalization algorithm: It is the histogram equalization that adapts to local changes in contrast
- Connected-component labeling algorithm: It is about finding and labeling disjoint regions

Dithering and half-toning algorithm: Dithering and half-toning include the following -

- Error diffusion algorithm
- Floyd–Steinberg dithering algorithm

Elser difference-map algorithm: It is a search algorithm used for general constraint satisfaction problems. It was used initially for X-Ray diffraction microscopy.

Feature detection algorithm: Feature detection consists of -

- Marr–Hildreth algorithm: It is an early edge detection algorithm
- Canny edge detector algorithm: Canny edge detector is used for detecting a wide range of edges in images.

Richardson–Lucy deconvolution algorithm: This is an image deblurring algorithm.

Segmentation algorithm: This particular algorithm parts a digital image into two or more regions.

- GrowCut algorithm: an interactive segmentation algorithm
- Random walker algorithm
- Region growing algorithm

Advantages and Disadvantages

III. CONCLUSIONS

It was shown that the 2DDCT method together with the brightness correction, fusion of features according to the current mean value of brightness as well as the removal of low-frequency components of the spectrum allows achieving higher efficiency of recognition in case of facial portraits having illumination problems – flashes, shadows, and very low-level of brightness. The paper presents an exact model of conducted experiments, the structure of corresponding FaReS, the implementation of its algorithm, and the results of tests executed on Yale B and Yale B+ databases. Obtained accuracy is better than the ones presented in [1-10]. Moreover, the proposed algorithm is much easier to describe and simple to implement.

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