Face searching by image partitioning, histogram equalizing and frames

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***Abstract* – The algorithms for image partitioning and parametric statistical features calculation is considered. The proposed features used for the face recognition approach. Histogram equalizing and frames were used to test algorithms.**

Keywords – parametric featuresж intensity; grid; fragment; pixel coordinates mean

I. INTRODUCTION

Nowadays there is a great number of articles, books and surveys considering a face recognition problem. Also many software products realizing different algorithms are described in different publications and Internet resources. Here we can mark only a small part of the algorithms and works given by the Google search. Many surveys and classification of face recognition approaches are given in the works [1-4] paying attention on knowledge based methods, neural networks, template-based methods and many others. Among them we can select statistical approaches with their important representatives: 1) Principal Component Analysis (PCA) estimates 2-D facial image as 1-D vector by concatenating each row (or column) into a long thin vector [5]; 2) Linear Discriminant Analysis in which every component has a different discrimination for identifying a person [6]. Linear discriminant collects images of the same class and separates images of different classes; 3) Support Vector Machine is based on the theory of statistical learning [7].

The majority of the above-mentioned approaches are quite complicated and time-consuming. The software of algorithms is not available. The present work suggests a much simpler technique for the retrieval of face image by the feature vectors. The technique is based on the fragmentation of the three-dimensional image intensity space forming fragments and segments.

II. PARAMETRIC STATISTICAL FEATURES FOR ONE LEVEL PARTITIONING

In order to obtain the three-dimensional surface of the image, first the color image is converted into the shades of grey. Every elementary cell, a pixel, assumes a value ranging from black to white, which we label as b – intensity (brightness). The range of all possible intensity values is within 0÷255.

Let us divide the image intensity space into n fragments by the horizontal planes XOY with an interval (intensity fragmentation step) d =255/n

Fragments or segments contain a large number of pixels which could be characterized by different distributed features. For example, the mean of the fragment or segment pixel coordinates:

$$\bar{x}(s)=1/k_s\sum X(s)\ ,\ \bar{y}(s)=1/k_s\sum Y(s)\,,$$

$$x_i \in X(s), y_i \in Y(s) \qquad (1,2)$$

where s – fragment or segment number, X, Y – sets of pixel coordinates.

To get a parametric feature connected with pattern coordinates, we divide a pattern surface by a grid with some steps by OX and OY coordinates (fig.1). The grid cells are numbered as 1, 2, …, Lx*Ly from left to right and down from a grid top. In every pixel fragment or segment the mean coordinates $\bar{x}(s)$, $\bar{y}(s)$ are associated with the cell number and its coordinates by corresponding formula:

$$C_n = (i-1)*L_x + j\,,$$

$$i = (\bar{x}(s)/L_x)_{ceil} + 1,\ j = (\bar{y}(s)/L_y)_{ceil} + 1 \qquad (3,4)$$

. Some mean coordinates of pixels in different segments or fragments have close values. By this reason they belong to the same cell. As a result the cell feature C_f has value equal to the number of segment (fragment) having the same cell coordinates. On fig.1 we can observe the face covered by a grid with some numbers in cells. Numbers and cells create parametric features of a dace covered by the grid 10x10.

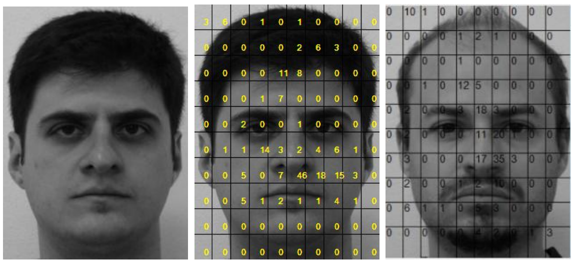


Fig.1. Faces : 1a, 6a covered by grid with mean numbers

In order to improve previous statistical features we correlate every coordinate mean with its intensity. So we get so called “cell – mean intensity feature. We can call them also “parametric” as depending from a step of the covering grid. For the faces 1a, 6a in Fig. 1 we have fragment and segment parametric features for grid 10x10 presented on Fig. 2

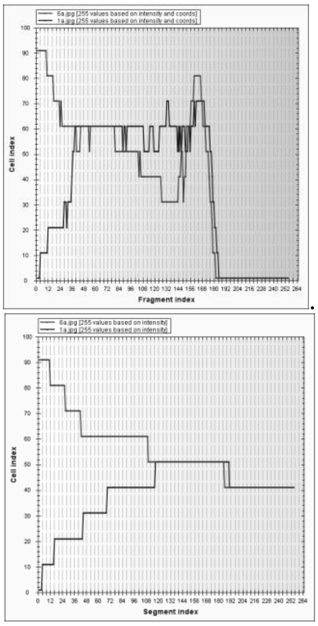


Fig.2. Fragment (a) and segment (b) parametric features

The less step of the grid the more precise parametric features are. Also from presented charts on Fig.4 we can conclude that the fragment features are more accurate and could be used for face and emotion recognition.

III. Preprocessing of frame extraction.

To investigate the problem what size of image and what type of histogram are better for recognition we consider the grid covering not a full face but its central part – so called frame. It contains the most essential and important information: eyes, mouth and nose. External zones including background are cut. An example of the 6a face cutting to get frame including covered by grid and features are shown on Fig. 3 (a,b).

a) b) c)

Fig. 3. Face with shadows (a), frame (b) and features on cells (c)

The next preprocessing procedure includes the image histogram equalized. Histogram is an array r[n] of numbers of pixels with concrete intensity n . The first step is to form a cumulative histogram :

$$r[i] = r[i] + r[i-1] \qquad (5)$$

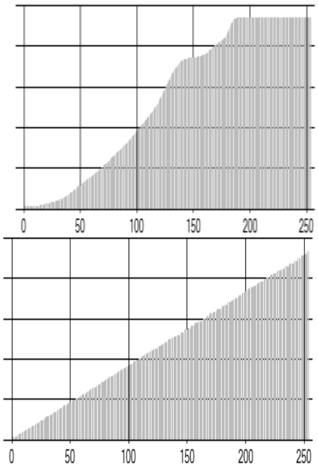
where r[n] – is number of pixels having intensity less or equal of n. The second step of algorithm calculates a new value of intensity

$$R(x,y) = r[oldR(x,y) \cdot Const] \qquad (6)$$

where $Const = \frac{255}{N}$, and N is a full number of image pixels.

An example of the 6a face with equalized histogram is shown on Fig. 3 (c).

Results of the 6a face histogram equalizing are shown on Fig.4.



a) b)

Fig.4. Histograms of the 6a face: original (a), equalized (b)

IV. Experiments

For testing, the database of 50 images of face pairs with different expressions from [8] has been chosen. Some searching experiments were held for the 6a face by differents features: of one level partitioning for intensity fragments and segment, with original and equalized histograms, for full size and framed images.. To compare the proposed methods and features and having no software of world known algorithms we have chosen as refference points the searching results of one algorithm.. To precise these points we use three algorithms : 1) full image and original intensity (segments), 2) full image and original intensity (fragments), 3) full mage and equalized histogram (segments).

Every face in the list has its own position, i.e. place number which as resulting refference points of these faces (in different algorithms) we use for etalon searchin result ($f_0(x)$ - a place number of he face (x) ..

All faces taking part in experiment are being signed by numbers got by searching and sorting. So, the evaluation function between etalon and comparative methods we calculate as follows

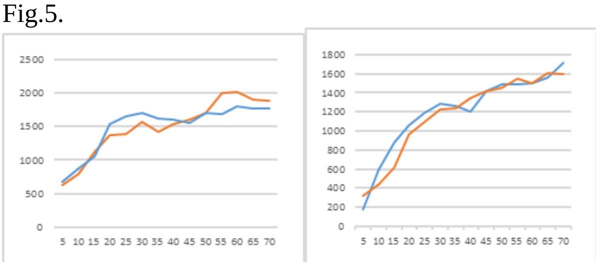
$$E_m = \sum_{x=1}^{W} \left| f_0(x) - f_m(x) \right| \, , \qquad (7)$$

where $f_m(x)$ - a place number of the face (x) in comparative algorithm..

Having evaluation function we can compare results of all developed algorithms with the etalon $f_0(x)$ features. For similarity we use the formula (8) only for 9 first faces.

There are two groups of experiments based on developed algorithms. In the first group we do experiments of face searching by fragment features of original and equalized histograms changing the frame sizes (two experiments; in the second group we do experiments of face searching by segment features of original and equalized histograms changing the frame sizes (also two experiments).

So we calculate the function (3) for 4 of 14 cutting experiments from 0 to 70 to compare searching results with the etalon list of faces. The function are shown on Fig.5.



a) b)

Fig.5. Fragment (a) and segment (b) similarity functions for original and equalized histograms by frame size

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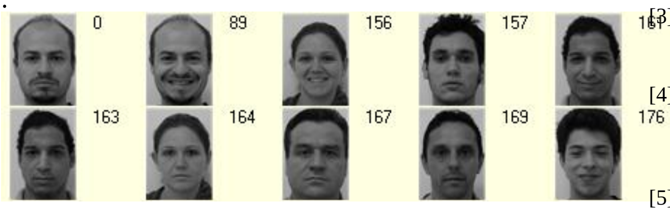

a)

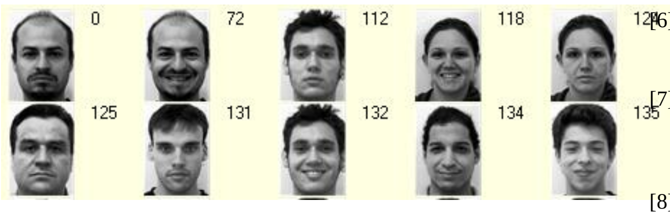

Fig.6. Faces from fragment features for original (a) and equalized histograms (b) and full image

We present results of four searching processes : by fragment features of full image with original histogram (fig.5 a), by fragment features of full image with equalizid histogram (fig.5.b), and the similary results for segment features (fig. a nd b) . The grid ws 10x10.

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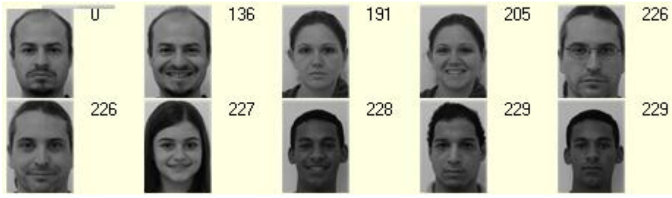

a)

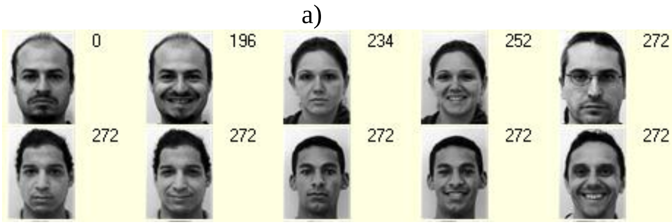

Fig.6. Faces from segment features for original (a) and equalized histograms (b) and full image

The experiments have confirmed that: segment features for face searching are more stable and less dependent from intensity changes..

Conclusion

The statistical parametric features of image and its intensity fragments and segments have been proposed. Some results of face image searching by frame cutting and histogram equalizing to investigate statistical features are presented.

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