# Пошук Облич з Допомогою Поділу Зображення та Параметричних Статистичних Ознак

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# Face Searching by Image Partitioning and Parametric Statistical Features

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***Анотація*—Представлено реалізацію алгоритмів поділу зображення на частини та обчислення статистичних ознак цих частин. Алгоритми застосовано до пошуку обличчя в базі даних. Наведено порівняння з різними способами формування ознак зображень.**

***Abstract*—The algorithms for image partitioning and parametric statistical features calculation is considered. The proposed features used for the face recognition approach. For the same data base the comparison results with different algorithms are presented.**

***Ключові слова—параметричні статистичні ознаки; сітка; фрагемент; середні координати пікселів***

***Keywords—parametric features, 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

### *A. Algorithm “cell - number of means” (A1)*

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:

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

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

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:

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

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

. 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. In 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.

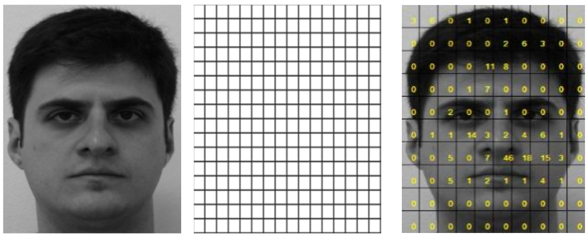
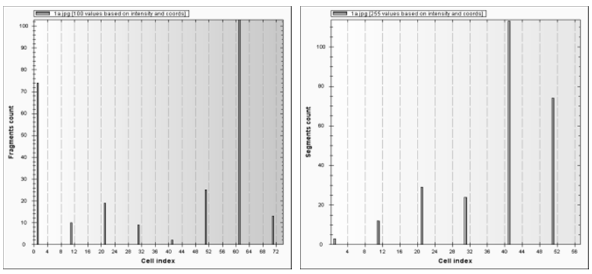


Fig. 1. Face, grid and mean numbers

Another representation of parametric features is realized with a chart by two coordinate axis: 0-$C_f$ and 0-$C_n$. For one face decomposition by fragments and segments two examples of charts are given in fig. 2.



a) b)

Fig. 2. Cell value by cell numbers in fragments (a) and segments (b)

In both representations features and their numbers are the same cell position and cell value. A grid dimension defines a number of features.

*B. Algorithm "cell—mean intensity" (A2)*

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 four faces in Fig. 3 we have fragment and segment parametric features for grid 10x10 presented in fig. 4.

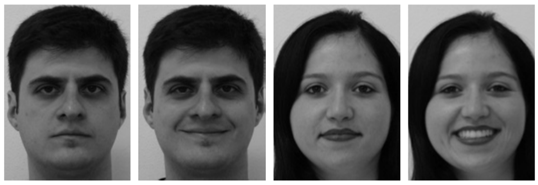


Fig. 3. Fragment and segment parametric features (5x5)

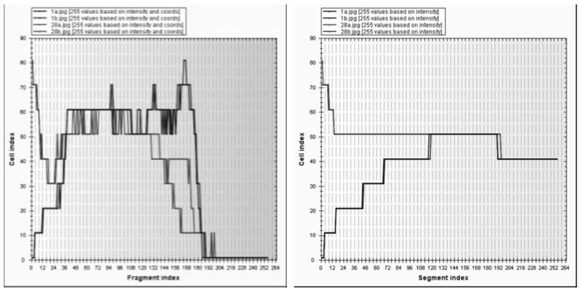


Fig. 4. Fragment and segment parametric features (10x10)

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

*C. Algorithm "mean intensity - row'" (A3)*

To compare the methods effectiveness one more statistical feature was developed. We consider an image as of pixel intensity. So for every row or column we calculate the mean intensity by following formula:

$$\overline{B}_j = 1/H \sum_{i=1}^{H} b_{i,j}, 1 \le j \le W, \ \overline{B}_i = 1/W \sum_{j=1}^{W} b_{i,j} \quad 1 \le i \le H, \qquad (5)$$

where $b_{i,j}$ – pixel intensity in the $i$-th row and $j$-th column.

The charts (5) of 50 faces of column and row features are shown in fig. 5.

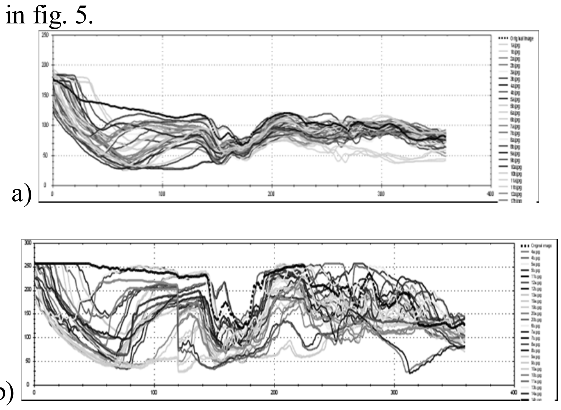
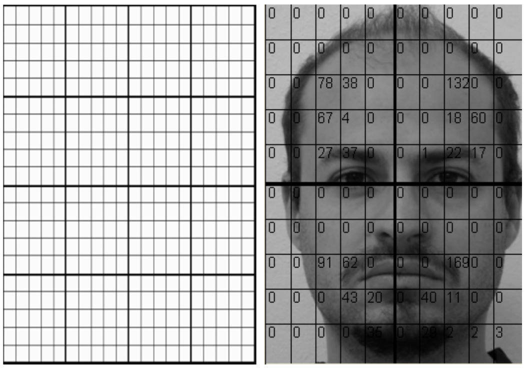


Fig. 5. Distributed mean intensity values by columns (a) and rows (b)

## III. TWO LEVELS OF FACE PARTITIONING

### A. *Algorithm "two levels - mean" (A4)*

As we can see from Fig.1,2 the cell value feature has many null elements. So, to get more information we cover a face image by a grid with two levels of partitioning. For example, grid on Fig.6 has basic division with 20x20 cells and additional one with 4x4 (or 2x2) cells. So, we consider every bigger part covered by its own grid separately. The resulting grid has much less null elements doing the majority of cells informative (fig. 6).



a) b)

Fig. 6. Grid with two level (a) and features in cells (b)

### B. *Preprocessing of frame extraction*

One more approach considers the grid covering not a full face but its central part – so called frame. It contains the most essential and essential information: eyes, mouth and nose. External zones including background are cut.

One example of face cutting to get frame including covered by grid and features are shown in fig. 7.

a) b) c)

Fig. 7. Face with shadows (a), frame (b) and features on cells (c)

## IV. COMPARISON OF METHODS

For testing, the database of 50 images of face pairs with different expressions from [8] has been chosen. 14 searching experiments were held for the 6a face: by differents features of one level partitioning and two levels partitioning, parametrica and mean features of full faces and frames. The experiments were held for fragments and segments of intesity. To compare the proposed method and having no software of world known algorithms we have chosen as refference points the searching results of our "mean intensity – row" (A3) algorithm. To precise these points we use three algorithms: full image and full intensity - mean intensity in rows, frame image and full intensity - mean intesity in rows, frame image and image segment (t=80) – mean intesity in rows. An example of a spread of the features given by the last algorithm is shown in fig. 8. In this figure we can see how charts (280 points) differ by intensity and shapes.

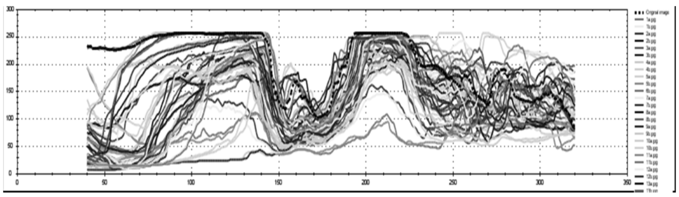
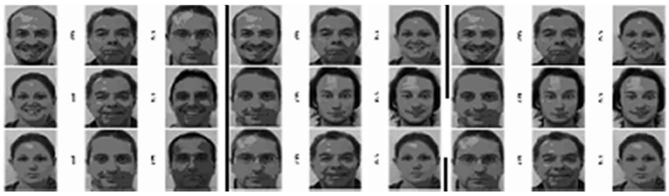


Fig. 8. Mean intensity in rows for segmented frames of 50 faces

Nine first representatives (a lack of article space is the reason) from 50 resulting faces given by three algorithms are shown in fig. 9.



a b) c)

Fig. 9. Resulting faces (9) for full images (a), for frames (b) and segmented frames (c) by mean intensity in row algorithm

Every face in the list has its own position, i.e. place number. As resulting refference points of these faces (algorithms) we use mean place number:

$$f_o(x) = 1/3\sum_{x=1}^{3}\left|f_i(x)\right| \tag{6}$$

where $f_0(x)$ – a place number of the face $(x)$, $f_i(x)$– a place number of the same face in reference algorithms.

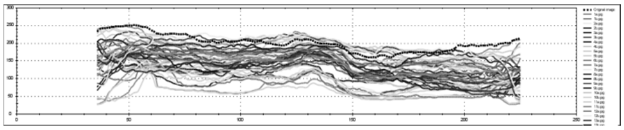
All faces taking part in experiment are being signed by numbers got by searching and sorting. So, the evaluation function between etalon and comparative methods we calculate as follows

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

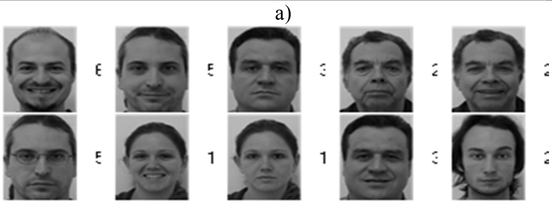
where $f_m(x)$ – a place number of the face $(x)$ in comparative algorithm.

Having evaluation function we can compare results of all developed algorithms with the etalon $f_0(x)$ features. For similarity we use the formula (7) only for 9 first faces.

There are three groups of experiments based on algorithms A3, A1, A2. In the first group we do six experiments: by columns and rows and for full images, frames and segmented frames. Evaluation function values are being inserted into the table 1. One experiment – the mean intensity in columns of segmented frames and first 10 faces – is illustrated in fig. 10.



a)

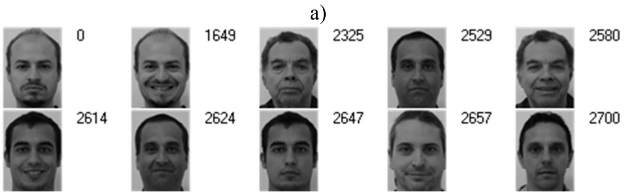


b)

Fig. 10. Mean intensity in columns for segmented frames of 50 image (a) and closest faces to the image 6a (b)

From the second group of experiments we illustrate by two groups of resulting faces got by the algorithm A1 for the segment and fragment intensity features. In fig. 11 we can see ten faces found for one level grid (12x15).


a)

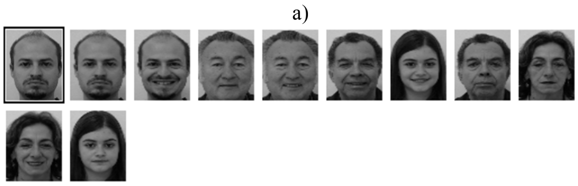



b)

Fig. 11. Searching results segment features (a) and fragment features (b) by grids of 12x15

All evaluation values of four experiments fith A1 are inserted into the table 1. Also four experiments were held with algorithm A2. On fig. 12 we can see ten first faces found for the grid 12x15 by intensity segments and fragments.

a)



b)

Fig. 12. Results for segments (a) and fragments (b) with grid 12x15

TABLE I. COMPARATIVE RESULTS OF FACE SEARCHING

| **Methods** | | **Evaluation function** | | |
|---|---|---|---|---|
| | | ***Full image*** | ***Frame*** | ***Frame segm.*** |
| A3 -rows | | 22 | 10 | 10 |
| A3 -columns | | 19 | 15 | 18 |
| A1 | frag. | 37 | 34 | - |
| | segm. | 33 | 31 | - |
| A2 | frag. | 41 | 36 | - |
| | segm | 38 | 34 | - |

The experiments have confirmed that: 1) first results from different features are not the same, 2) some pictures that are close to the request are being repeated in different experiments, 3) results are sensitive to parameters i.e. grid dimension, mode of intensity decomposition etc. Maybe partly responsible for such results are cumulative histograms of images which differ between themselves essentially. So, preliminary preprocessing is needed particularly for grid methods.

## V. CONCLUSION

The statistical parametric features of image and its intensity fragments and segments have been proposed. Some results of face image searching and comparison of approaches are presented.

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