BARCODE GENERATION FOR FACE IMAGES[1]

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The paper addresses the problem of linear barcode generation for face images. The history of the problem and possible approaches to its solution in mobile oriented systems are discussed.

Two methods are presented: the first one is based on intensity histograms, and second one is based on intensity gradients, calculated over images using their original features. Then these features are averaged over limited number of intervals, quantized in the range of decimal digits from 0 to 9 and converted into standard barcode. Structure of barcode generation system is proposed, and description of its blocks is presented.

The methods have been tested by using «Face94», «Face Sketch FERET Database» databases, as well as a database composed of different age faces. The tests have demonstrated invariance of barcode in respect to changes in local sizes of face images, in tilt in the XY plane, to changes in the view, mirror rotation about vertical axis, as well as changes in facial expressions and age-related face changes.

Therefore, the presented methods constitute novel solutions to practical applications in real conditions of dynamical parameters changes in face images. Moreover, both methods require neither big computational resources, nor using of special software packages for image processing, allowing generation of linear barcode in real time systems. A generated standard barcode contains information about a person's face and can be used for indexing, identification, recognition, and searching for people.

Key words: face images, barcode, real time systems.

Introduction

Barcode encoding techniques are used for various goods identification, in finance documents, payments, advertising materials and services, and have established wide and everyday applications. Reading of barcodes is fast and simple by using specialized tools, and comprehension of their content poses no problem, because decoding is solved in the frame of list search.

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Standard barcode for people identification was proposed for the first time ever in the patent [1] only in 1999. It was assumed that identification took place when making electronic payment – i.e. in real time, by using the unique barcode printed on his hand and read by special head.

But this technique of people identification with barcode has not found wide application, despite implementation of biometrical standards for anthropometric identification, and biometrical methods of people identification have better ability than people themselves. Barcode printed on skin, however, are now advertised as fashionable tattoo [2]. Barcodes printed on skin does not contain any biometrical characteristics of a person [2]. But we can expect with certainty that if a barcode contains some biometrical characteristics, it will be accepted not only as «fashionable token» but also as usable way of people identification. It is hard to imagine the way of identification using barcode hidden under the clothing, or on the body in hardly accessible place and uncomfortable for reading, as presented in *Fig. 1.*

Fig. 1. Examples of tattoos [2]

An ideal solution will be to generate a barcode only when it is needed, and in real time – e.g. based on face or voice. In such case identification can be made «from distance» – and not observable by an individual, not requiring any activity and storing generated code on his/her skin.

Assuming that such task can be solved in principle, obtained solution can be used to encode a face image or voice in the form of barcode. Such codes can be used in mobile biometrical systems of access control AC, portable interface systems «man – computer» for user identification, for people recognition in video monitoring systems recording face or/and voice.

This paper will focus on one of possible information sources: face or voice, i.e. face images, presenting a problem leading to solution, it implies encoding face image with a barcode. In practice of using face image as the source of biometrical information in the form of barcode a problem is associated with dynamical change of image parameters in real conditions (e.g. tilt and direction of face region in the image, image intensity and facial expression). This means that basically it is impossible to represent a face image using invariant features, which don't depend on dynamic changes in mentioned parameters. As a result, the lack of invariance leads to generation of unstable barcodes, independent of its form. In AC systems variability of input face images is not big, because of using stable image exposition conditions (face illumination, controlled rotation and face expression, etc.), also in this application obtaining stable barcodes is problematic.

For these reasons the problem of stable representation of face images with barcodes has remained relevant, practically since the first application of a computer system for people recognition based on their face images, also for intensively developing mobile systems, using new technology base – tablets and smartphones.

1. Short review of existing approaches

10 years after submission of the patent [1], psychologists S.C. Dakin and R.J. Watt noticed in their paper [3], that all information about human face is contained in horizontal lines, like eyebrows line, eyes line and lips line. In addition, they have shown that this information can be successfully represented as a set of white and black lines (i.e. as some kind of barcode, named «biological barcode» by the authors), paying attention to some invariant characteristics of «biological barcode of human face».

Example of this representation of face region is shown in *Fig. 2*, where: *a* – original face image; *b* – variant of extracted face characteristics; *c* – «biological barcode» of human face; *d* – variant of standard barcode, representing required solution.

However, in the paper [3] and further publications of these authors (e.g. [4]), they have not presented any algo-

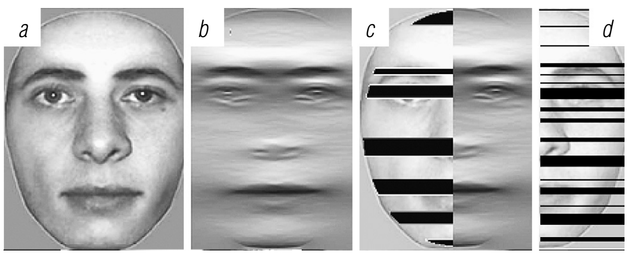

Fig. 2. Ways of representing face region [3, 4]

rithm for generation of similar barcodes, and concluded that representation of face region only using thick white and black bars cannot be the exact model of a specific person face. Such model constitutes precise «biological barcode of face», at the same time it represents «very rough approximation» of specific person face, what is visible in *Fig. 2*, comparing its «*c*» – «*d*» parts.

Approximate character of this representation is associated with the morphology of human face – it is very difficult to detect border hair/forehead, border lines of eyebrows and their specific features, borders of eyes lines, border of nose line and lips and even more difficult to describe these by using thick straight lines. More precise representation requires thinner and more complicated set of lines. It is possible that human face and corresponding barcode could looks like presented in *Fig. 2d*, as was suggested in [5].

Within five years the most important experimental investigation concerning face representation with barcodes has appeared [6]. The authors have presented an algorithm to generate face barcode HCC2D, encompassing advantages of two-dimensional code HCCB (High Capacity Color Barcode) and two-dimensional code QR, distinguishing high density of information concentration. In the framework of real time and mobile systems, using tablets and smartphones, the algorithm proposed in [5] has little chance to be implemented in the near future. Such conclusion can be supported by two serious flaws of the algorithm for generation of two-dimensional color barcode HCC2D:

✦ the algorithm [6] implements a rather complicated process of singular (key) points searching in face image and the algorithm for describing its neighborhood by using SIFT (Scale Invariant Feature Transform) and SURF (Speeded Up Robust Features) procedures;

✦ the result of singular (key) point search with SURF algorithm is not invariant in scale, requiring in consequence decomposition of an original face image into pyramid of multiscale regions and multiple run of SURF method for each region of the pyramid (making the whole algorithm of key points searching even more complex).

Consequently, the algorithm presented in [6] for generation of two-dimensional color barcode HCC2D requires high throughput computer system, supported with dedicated image processing software packages.

Finally, representation of face image by two-dimensional code (i.e. HCC2D) is a departure from the concept of linear «biological barcode» [3] and will not be considered further in this paper.

The closest to the concept of linear «biological barcode» is the algorithm presented in monograph [7, pp. 170 and 214]. *Fig. 3* illustrates the concept of this algorithm.

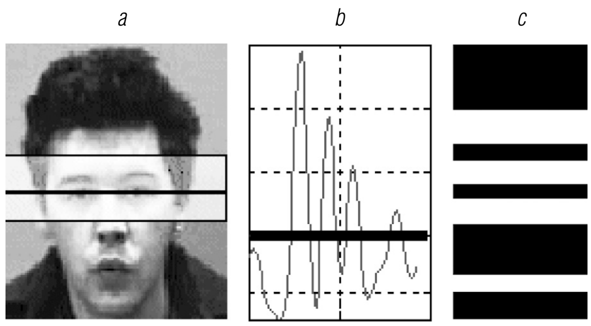

Fig. 3. Diagram of forming binary codes [7]

At the first phase the intensity gradient for symmetrical (mirror) located windows slides over a face image in top – down direction, as shown in segment *a*. Then the difference between current values of gradients and their mean values is calculated, and obtained differences are coded. Differences of gradients, which are less than mean value, are coded as «0», and those, which are greater than mean value, as «1», resulting in binary like code, representing each original image. The form of resulting code is similar to «biological barcode» [3]. These results are shown in *Fig. 3* segments 3: *b* – current gradient values and its mean value; *c* – «biological barcode» for original image.

This approach [7] has the drawback, namely we cannot obtain the same binary code for face images of the same person, but taken in different exposition conditions. Such changes include small, but «eye» perceptible changes in face region size, its tilt (in plane XY), face expression and difference in intensities of some face areas caused by local shadows. This flaw makes application of the mentioned approach impossible in situations with dynamical changes in face image expositions described above, and consequently in transforming face images into the corresponding code.

General appraisal of presented methods of transforming face image into binary code suggests, that they can be used only in case of classification of generalized class of «human face images» among other classes of images, not containing faces, as was stressed by the authors of [3, 4].

This paper proposes two possible approaches for representation of a human face in the form of linear barcode of type EAN-8, EAN-13 (or UPS) in conditions of perceptible dynamical changes of face image parameters. Both approaches require neither big computational resources, nor specialized software packages for image processing, making possible their applications for generating linear barcodes in real time within mobile systems.

The paper is organized as follows: section 2 presents the structure and function of the barcode generation system, section 3 presents structure and functions of the barcode generation system corresponding to input face image, section 4 describes the algorithms used to generate a barcode based on face image intensity histogram, section 5 is devoted to the barcode generation algorithm based on face image difference gradients. Results of testing of the proposed algorithms and examples of generated barcodes are presented in section 6. The paper ends with short commentaries and bibliography.

2. Barcode generation system

The structure of the barcode generation system is shown in *Fig. 4*; it is composed of of four basic blocks: 1 – input image preprocessing; 2 – feature extractor 3 – feature encoding; 4 – barcode generator; system input and output.

System input receives an image and produces a standardized barcode corresponding to an input image. Taking as an example the AS system, we formulate the input image requirements.

The reason for selecting this application is that in AC systems a person standing in front of the camera is asked to fulfill recommendations concerning stable exposition conditions – i.e. taking the front view with neutral face expression. These requirements are necessary in order to obtain a stable barcode. In practice, however, it is hard to meet these conditions, and we are forced to allow some variations in face images input to the AC system. An example of allowed variations is presented in *Fig. 5a* (taken from source [8]).

These variations concern: face area size, tilt in XY plane, face expression, as well as intensities in some regions of face (caused by local shadows or spectacles).

As mentioned, block 1 (input image preprocessing) executes two basic tasks. The first one is input image analysis with its parameters estimation – size, range of colors and deflection of eye line from horizontal line. The second one implies rotation in XY plane, and correction of image size and intensity equalization, if necessary as a result of the analysis. Such problems are discussed, e.g. in monograph [6].

Often in bimodal AC systems input data include image and voice. Then face expression changes while uttering some control word, sentence or during conversation. An example of images in mentioned situations is presented in *Fig. 5b*. Ensuring stable image encoding in cases presented in *Fig. 5* and *6*, depends on selected features for face representation. This task is solved in block 2 (feature extractor). At least, two approaches are possible.

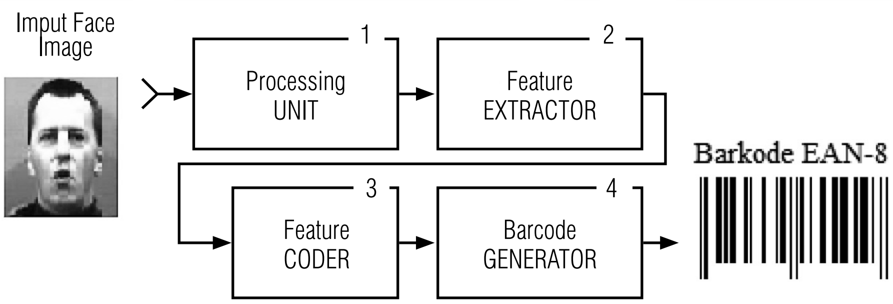

Fig. 4. Structure of system

Fig. 5. Possible changes of face image

The first approach involves representation of the whole input image using a set of features that ensures imperceptible influence of face expression. The implementation may be based, for example, on intensity histogram of input face image. As shown in [7, 9], the histogram gives high efficiency of image retrieval in big databases and frequently is the only facility in CBIR applications (Content-based image retrieval).

The second approach is feature extraction using only 3/4 of the top part of a face image, excluding the part below the middle of the nose/mouth segment (shown in Fig. 5b). The top part of face is not influenced by utterance, ensuring stability of representing its features.

In both approaches block 3 addresses the encoding task using by the necessary number of decimal digits. This is achieved by averaging the features to a limited number of quantization intervals and quantizing these in the range of decimal digits from 0 to 9. This stage eliminates the influence of dynamic change of input image parameters, which have not been taken into account at the earlier stages, on encoding result.

In this case the task of block 4 is trivial – to change the encoding result obtained in block 3 based on algorithm of a standard barcode generation [10]. Generation of a standard barcode includes evaluation of code checksum produced in block 3 and transformation of this code into a binary matrix, representing input image in graphic form of a standard barcode.

The approaches presented in this paper enable to generate linear barcodes based on face images in EAN-8 format and can be used to obtain other linear barcodes, e.g. EAN-13 and UPS [10].

3. Barcode generation based on histogram

We assume that an input image with GRAY scale has got size $M \times N$. Our task is to represent this image in the format of EAN-8 barcode.

To generate EAN-8 barcode we have to calculate the intensity histogram of an original image and to convert it into a code consisting of 7 decimal digits. Therefore, for the histogram calculation we have chosen the initial value of the parameter bins ≥ 7. Let $bins = 8$, then the histogram of the input image evaluated originally for 256 intensity levels (from 0 to 255) will be averaged exactly in 32 intervals. As a result, we obtain a histogram H with the values of $H(b)$, for $b = 1, 2,...,8$.

The next stage implements the preliminary encoding of histogram values:

$$\overline{H}(b) = f[scale\ (H(b) / max(H))],\ b = 1,...,8,$$

where: f [·] – the nearest integer value (removing the remainder); scale – *scale* factor, $9 < scale < 10$, is not an integer.

In this case values of histogram are quantized in the interval decimal digits from 0 to 9. As a result we have got the decimal number encoding with 8 digits. Subsequently, the formation of EAN-8 barcode involves only seven digits, for example, from the 1st to the 7th, or from 2nd to 8th.

Then the result is converted into the final EAN-8 barcode, consisting of 8 digits, and the 8th digit identifies the checksum for the first 7 digits. For this purpose we apply the standard algorithm, as in [10].

In conclusion, please note the following: evaluation of input image histogram requires neither big computational resources, nor special software packages for image processing. This enables to generate a barcode with «histogram method» by using the mobile systems. Moreover, most of them have built-in face area detection function, as well as barcode reading programs. Such program can be easily adopted for synthesis of barcode based on given decimal number.

4. Barcode generation based on difference gradients

This method is based on intensity difference gradients of an input image, averaging of gradients on the limited number of intervals, quantizing the result in the range of decimal digits from 0 to 9 and transformation into standard barcode according to a table.

Let an input image with GRAY scale have the size $M \times N$. Original feature extraction for the given input image is based on the calculation procedure of intensity difference gradient of two symmetrically located windows with height $H \geq 1$ pixels and length equaling the width of an input image. Windows are shifted over a face image with step $S \geq 1$. Windows move only in vertical direction from top to bottom; and for each step the distance (e.g. euclidean distance) between corresponding fragments of image is covered by the windows. Shifting of windows starts in practice on the border «hair/forehead» and finishes on lower border of nose, or just beneath nose. Difference gradients in windows, transformed into distance, enhance jumps in intensity on the border hair/forehead, borders of eyebrow line, eye line and the line nose/lips – i.e. along the lines of «biological face code». Calculated distance values represent integral

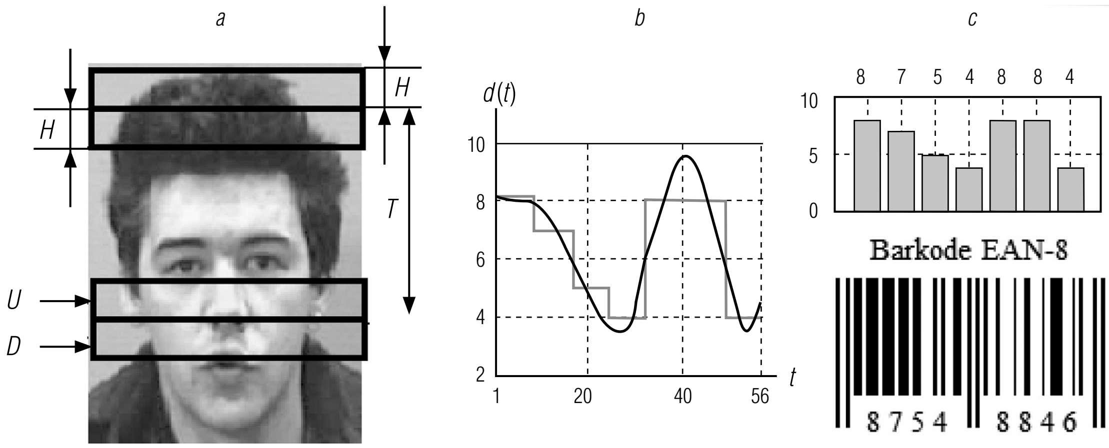

Fig. 6. Clarification of gradient method

characteristics of the least variable part of a face under the condition of discernible dynamical changes of face image parameters.

The idea of forming difference gradients and their encoding by using the windows is clarified in *Fig. 6*, where we use the following descriptions:

The total number of shift steps is $T = LA$, where L – code length, and A – smoothing interval.

Generation of the barcode in EAN-8 format, $L = 7$, and the parameter $A \geq 2$, generally chosen from the condition of border intersection

$$T = LA \leq (M - H). \qquad (1)$$

The value of T should, for instance, touch the lower border of nose or be between nose and mouth, in order to exclude the lower part of a face, thus eliminating the influence of face expression on stability of generated barcode. From the other side, if the value of $T > (M - H)$, then it will be necessary to increase the size of input image in order to meet the condition (1). Increasing is executed in block 1 at the stage of image size correction, as described above.

Now we can determine the distance $d(t)$ between these windows:

$$d(t) = \| U_t - D_t \|, \forall\, t = 1, 2,.., T, \qquad (2)$$

and normalization result:

$$d(t) = d(t)/max(d),\ t = 1,...,T. \qquad (3)$$

The results obtained in (3) are averaged within interval A and quantized in the range of decimal digits from 0 to 9 using scaling factor scale:

$$\overline{d}(l) = f[\frac{scale}{A}\sum_{j=1}^{A} d(A(l-1)+j)],\ l = 1, 2,..., L, \qquad (4)$$

where: $f[\cdot]$ – the nearest integer value (removing the remainder); scale – scale factor, $9 < scale < 10$, is not an integer.

The result calculated according to (4) from output of block 3 is fed at input of block 4, where the final barcode is formed, consisting of 8 digits. To this end we have used the standard algorithm described in [10].

The result calculated in (2)-(4) is shown in *Fig. 6*: b – normalized values of distances and their thresholding in averaging intervals A (broken curve); c (upper index) – representation of thresholding result in the form of 7 digits barcode; c (lower index) – resulting barcode.

5. Experiments

5.1. Tests of «histogram method»

The test is composed of 4 computer experiments: two with «Face 94» face database [8] and two with CUFSF database (CUHK Face Sketch FERET, [12]); and extended modification presented in [13].

The experiments with «Face 94» database have used 100 classes each containing 20 images, and EAN-8 barcodes have been generated. Input images of size 200× 180 pixels have been transformed into GRAY format. No other image analysis and rotation operations have been carried out to obtain horizontal orientation of eyes line, although, as mentioned above, parameters of images were not very stable, as required, e.g. in case of AC systems. The barcode generation process has been controlled by selecting the following parameters: *bins* = 8; *scale* = 9.

A portrait with number 1 was selected from each class, and barcode was generated for the first seven values of the histogram. Then barcodes were generated also for remaining nineteen portraits of each class (from number 2

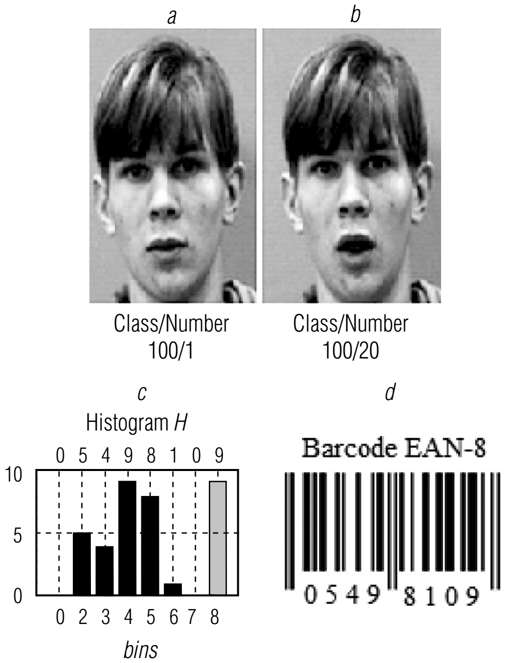

Fig. 7. Test results using «Face94» database

to 20) by using the same encoding control parameters. The test results for all 100 classes gave 670 related image pairs, having the same code. These related pairs belong exclusively to their class, giving 6 to 7 images per class. It is important to note that face expressions related to speech presented no hindrance to generate the stable barcode.

These test results are shown in *Fig. 7* and present: *a* and *b* – input images (1st and 20th in class 100); *b* – histogram, consisting of first 7 values (dark strips) and the value of checksum (light strip); *c* – barcode.

Further 6 tests – checking the stability of generated barcodes obtained for reduced size images – reduction by 10%. For example, if the size of an input image is 200 ×180 pixels, the size of smallest one is – 80×72 (40% of input image). The total number of generated barcodes for 6 tests amounts to {661, 671, 665, 673, 675, 620} also with complete lack of doubling between classes. These results have shown that barcodes generated using intensity histograms in all conducted tests have no doubling errors. The pair number of identical barcodes changes slightly in each test, confirming the stability of this method. We can note that the barcodes have not been changed with mirror rotation of test images around the vertical axis as well as rotation by 90^o (right/left). This «invariance property» of intensity histogram makes this method applicable in real life with different variants of people images (we can call these conditions as «mobile photography»).

Experiments involving sketches were conducted with 100 classes of database [13]. Each class contained 10 sketches, the first one is the original sketch from CUFSF base [12], remaining 9 are its modifications. The modified sketches differ from the original – these have different size of the face area, shifted up or down of the central part of face, disturbed symmetry of the face area. With mentioned modifications the phase correlation between the original sketch and its modifications is on average close to 0.2 that confirms the importance of these modifications [13]. Control parameters for barcode generation had the values *bins* = 8; *scale* = 9. Control barcode was generated from original sketches, and their 9 modifications were used for the test. The tests results for total 100 classes gave 524 corresponding pairs of sketches (from 900 tested), which had the same barcodes. These corresponding pairs belonged exclusively to their respective classes, amounting to 5 or 6 sketches per class. In the experiment four pairs of classes had identical barcodes, and this can be attributed to «non-specific texture» of images, showing the sketches. However, selecting histograms with *bins*> 8 and using barcodes EAN-13, probability of doubling is practically excluded.

Fig. 8 illustrates the result of the second experiment for sketches.

Here the following parameters are shown: *a* – the original sketch from CUFSF database [12]: *b* – a modification of the first image (changes in the size of the face area with effect similar to «fish eye»); *c* – the intensity histogram is shown in the form of 0012211111234598 consisting of 16 decimal digits (this histogram is identical for two presented sketches); *d* – variants of EAN-8

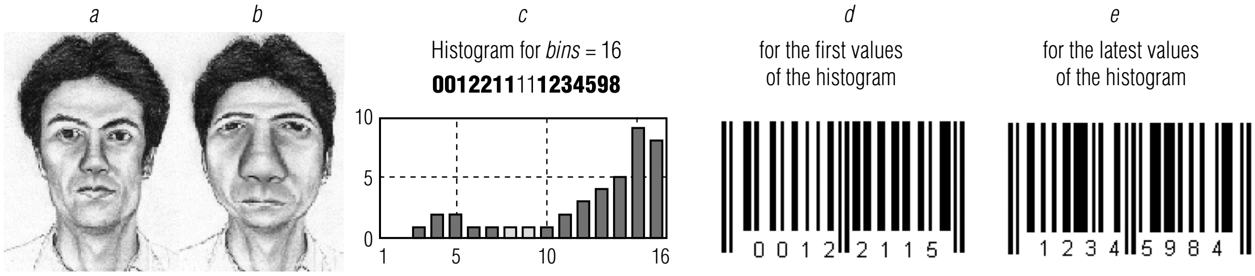

Fig. 8. Result of experiment with CUFSF database

barcode evaluated on the first seven values of the histogram; *e* — variants of EAN-8 barcode evaluated on the last seven values of the histogram. These results show that changes in the sketch parameters had no influence on the stability of generated barcode.

But in real conditions we can expect some problems with application of the histogram method. In case of AC systems, which use separate lighting of face, and in case of certain face database, the histogram method provides very stable generation of a barcode in real time.

5.2. Tests for «gradient method»

Two experiments have been carried out for these tests: one — by using «Face 94» face image database [8] and the other — by using database of composed faces, representing face changes with human age [14]. «Face94» database consists of 100 classes, 11 images in each class, for which EAN-8 barcode was generated. Input images were transformed into GRAY format and scaled to the size 112×92 pixels. Images were not preprocessed in order to obtain the standard position of eye line or scale of anthropometric face characteristics.

In test 1 portrait number 1 was selected from each class, and its barcode was generated by using the following control parameters of encoding process:

$$\{H=23;\ S=1;\ L=7;\ A=8;\ T=56;\ scale=9.5\}. \quad (5)$$

Then the barcode was generated for the remaining ten portraits of each class (from number 2 to number 11) by using the same parameters of encoding process. As a result of testing all 1000 pair images were obtained, more than 700 related image pairs having the identical barcodes. These related image pairs belong exclusively to own classes. The example result for conducted test is illustrated in *Fig. 9*.

It is shown: *a* and *b* — the first and last image used in class 100; *c* — phase correlation between corresponding distance vectors (confirming nearly 100% of their similarity); *d* — normalized and quantized values of the distances presented in barcodes graphics; *e* — barcodes for two images. Correlation, as additional verification means, has been introduced into the test on purpose. We can note that in spite of variation in face expression, the same barcodes were obtained.

Fig. 10 illustrates the result of barcode generation for images with different face expression.

Here we have 2 pairs of images and corresponding barcodes generated in standard EAN-8.

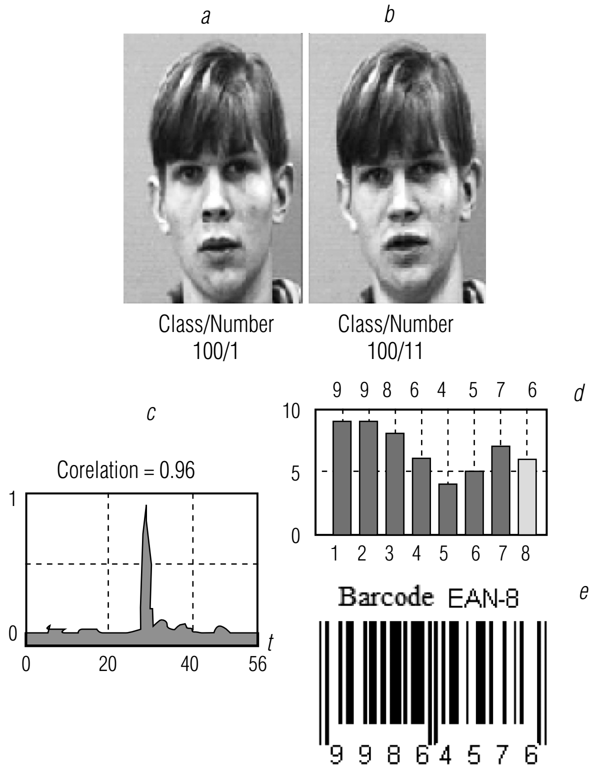

Fig. 9. Result for gradient method

We can observe the following: changes in face expression, changes of face area size, and changes in eyes area (open and closed eyes) have no influence on the generated barcode. The same results are obtained in extended test 1.

The next test aimed at checking the stability of the generated barcode after mirror rotation of input image, its preservation after additional dynamic changes of image parameters — local face size, tilt in XY plane, image rotation, changes in face expression and presence of local shadows caused by local lighting. The obtained results are illustrated in *Fig. 11*.

Fig. 10. Example results for images with different face expression

Fig. 11. Example results for images with mirror symmetry

Face images for each class (from number 2 to number 11) were mirror rotated about vertical axis, and the barcodes were also generated for such images. Here we can see that mirror rotation has not changed the barcodes.

The goal of the last test is to check the stability of the generated barcode with face «aging». The experiment was conducted with 38 composite faces, representing changes with human age [14] from 20-24 up to 61-64 years. The following encoding parameters were used:

$$\{H = 22;\ L = 7;\ A = 7;\ T = 49;\ scale = 9.7 \div 9.9\}, \quad (6)$$

and the parameter *scale* could have any value in the indicated interval. We can note that independent of face aging, for all of them we have get the same barcode.

The final results are illustrated in *Fig. 12. Fig.* description: in column *a* and *b* – faces in age of 20-24 и 60-64 years; in column *c* – phase correlation change and similarity index for the whole range of image changes (face ages), and *d* – normalized and quantized values of the distances, presented in barcodes graphic and standard barcode for input images.

All 38 images have the same barcode. This experiment has shown that in the framework of difference gradient and with parameters (6) the barcode remains unchanged with face aging modeling.

Conclusion

The paper has discussed the problem of generating linear EAN-8 barcodes from facial images. The history of the problem has been presented, and possible approaches for mobile systems have been formulated. Two methods have been proposed: the first one is based on the intensity histogram as invariant features, which represent the original image of a face, and the second one relies on intensity gradients calculated over images using their original features also representing the characteristics of face images. Testing has been performed at the stage of the computer simulation. The tests have been conducted by involving «Face94», «CUHK Face Sketch FERET» bases and the base of composite faces simulating aging. The test results have shown that the proposed methods ensure the stability of the generated barcodes in case of mirror reflection of the original image, when there are scale, pose and facial expression variations and when there are shadows on facial images from local lighting. Furthermore, the method generates the standard barcodes directly from the facial images, and thus contains information about a person's face. In this case the generated barcode can be used for indexing, identification, recognition, and searching for people, and proposed by the methods determined by the direction of further research and applications of barcodes in practice. ■

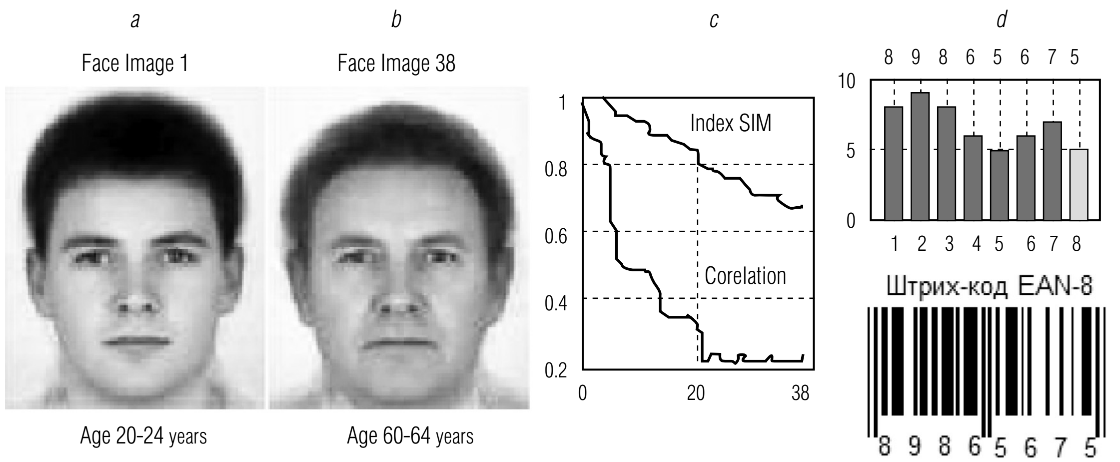

Fig. 12. Barcodes for face aging

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МЕТОДЫ ФОРМИРОВАНИЯ ШТРИХ-КОДА ПО ИЗОБРАЖЕНИЯМ ЛИЦ

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В статье обсуждается задача формирования линейного штрих-кода по изображениям лиц. Представлена история задачи и возможные подходы к ее решению с ориентацией на мобильные системы.

Для решения задачи предложены два метода: первый метод основан на гистограммах яркости, второй — на разностных градиентах яркости, представляющих изображения лиц в форме исходных признаков. Далее в каждом методе эти признаки усредняются на ограниченном числе интервалов, квантуются в диапазоне десятичных цифр от 0 до 9 и преобразуются в стандартный штрих-код. Предложена структура системы формирования штрих-кода и приводится описание основных блоков.

Тестирование выполнено на базах «Face94», «Face Sketch FERET Database» и базе композитных лиц различных возрастов. В рамках тестов показано, что сформированный штрих-код не изменяется при изменении локальных размеров лиц, наклона в плоскости XY, изменения ракурса и зеркального поворота вокруг вертикальной оси, а также при изменениях речевой мимики лиц и возрастных изменениях лиц.

Таким образом, предложенные методы предлагают новое решение для практики использования в реальных условиях — динамики изменения параметров изображений лиц. При этом оба подхода не требуют больших вычислительных затрат, а также использования специализированных пакетов программ по обработке изображений, что создает условия для формирования линейных штрих-кодов в рамках систем реального времени. Сформированный штрих-код содержит информацию о лице конкретного человека и может быть использован для индексирования, идентификации, распознавания и поиска людей.

Ключевые слова: изображения лиц, штрих-код, системы реального времени.

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