# OPTIMIZING FACE RECOGNITION IN IMAGES

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***Abstract:*** *The paper aims to optimize practical applications for detection and face recognition using Haar-Like classifiers in conjunction with a centroid algorithm to detect the gaze direction. For selecting method we have implemented principal components analysis (PCA), and for image resizing after detected we used the interpolation method. The proposed algorithm is tested by a database of its own and by training aiming at detecting and recognizing faces in crowds crowded. Practical application in Microsoft Visual Studio was held in CSharp using predefined elements in Open Cv. Finally we present comparative results with other three systems that implement biometric technologies, about false acceptance rate, false rejection rate, and processing time.*

**Keydords:** *recognition, image, technologies, processing, detection*

## 1. EXTRACTION AND SELECTION OF FEATURES THE CHOICE OF METHOD SELECTION. PCA VS. LDA

A performance analysis methods using PCA and LDA selection deploying two classification methods using SOM and Csoma was presented in [1].

We demonstrated by fusion of features on networks trained containing a number of 80-360 neurons with a step of 40 neurons that there is a great recognition for a single color component C1, over 95% using LDA and 74, 95% using PCA for involvement of more than 360 neurons.

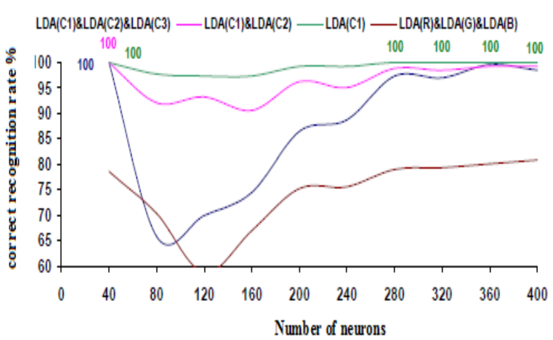



Fig. 1. Representation of performance results for LDA

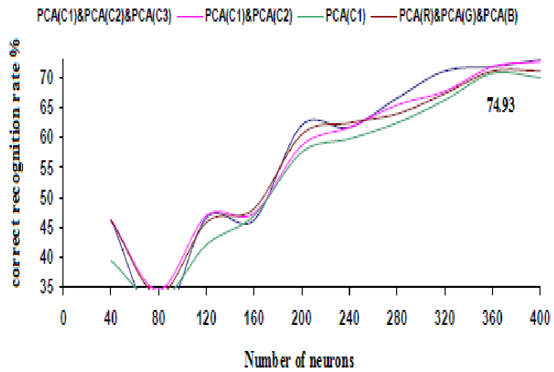



Fig. 2. Representation of performance results for PCA

The object of the military real-time recognition, we turned to recent studies have shown that training time approx. 40 ms can be achieved only by using PCA. LDA allows drives to dozens of minutes.

PCA also allows good image compression, Karhunen-Loeve transform for each 20 allowing every pixel images that we represent vectors each with 20 dimensions. Each vector can represent all of the same pixel intensity values of the photo-image analysis.

It should be mentioned results Turk and Alex Pentland Matthew who showed Laboratory Massachusetts Institute of Technology that is reasonable recognition using PCA by changing the image acquisition conditions with an angle of up to 45 degrees to the other schemes recognition using vector of the common face.

In reference [2] is demonstrated that PCA allows to describe variations between images of models with significant differences in features.

In reference [3] it was shown that using 16 subjects the three types of image formats by changing lighting conditions that the 6 types of resolution (512 x 16 x 16 ... 512), for a total of 2592 images entrained can get a correct recognition rate of 96%, above the normal lighting of the light 85% below to 64% above the size of the image. The results showed that the maximum 19% can be obtained by changing the lighting rejections, 39% and 60% by changing the orientation by changing the size of the acquired images.

All these considerations led us to the decision to use the selection method using PCA in practical applications performed in this paper.

## 2. THE CLASSIFICATION ITSELF

Implementation of neural structures as forms of visual classifiers is one of the most common applications of neural networks. The training of a neural network for visual pattern recognition (2D or 3D) requires, in principle, the approach has three distinct directions, generic schematic below:

(1) {visual forms (2D or 3D)} entry extraction / selection shape descriptors (1D) {lot of training (1D)} standard neural network;

(2) {visual forms (2D)} input {lot of training (2D)} specialized 2D neural networks;

{Visual forms (3D)} entry extraction / selection projections (2D) {lot of training (2D) 2D specialized neural networks;

(3) {visual forms (3D)} entry extraction / selection shape descriptors (3D) {lot of training (3D)} 3D specialized neural networks.

Neural networks listed in the previous paragraph (2) are specialized structures involvement with 2D input forms, the flexibility organization of neurons in the input layer in the form of two-dimensional arrays of different shapes (circular, hexagonal, etc.).

An efficient method which eliminates the step neural classification of feature extraction is disclosed in reference [4].

Essentially, the method consists in transforming space training vectors into a new space whose dimension is equal to the number of classes.

Such vectors are transformed pseudo-features are subsequently presented a classical multilayer networks.

Finally, it must be made and natural observation that because of fast development and implementation of new structures of neural networks, neural computation range theory applied in pattern recognition (visual) is much larger, far exceeding the possibilities of coverage and presentation in an article.

## 3. CUBIC INTERPOLATION

Resizizing and image detection for forced comparing the same size as the test image was performed using cubic interpolation methodology.

This approach assumed predefined approximation techniques based on Spline function.

It was proposed that computer application, after applying interpolation to achieve:

-Display the added image to a grayscale

- Save a text file of faces involved

- writing the labels of involved faces in a text file for loading and subsequent detection

Interpolation is a method of estimating the values applied in a location without measurements, based on measured values in neighboring points.

The process consists in finding a function f (x, y) to represent the entire surface z values associated with points (x, y) arranged regularly performing a prediction function z values for other positions arranged regularly.

The considerations that led to the choice of interpolation were offering a large space for data input processing, a very short time and the possibility of implementing applications using open source.

Implementation method of spline functions in the process of cubic interpolation.

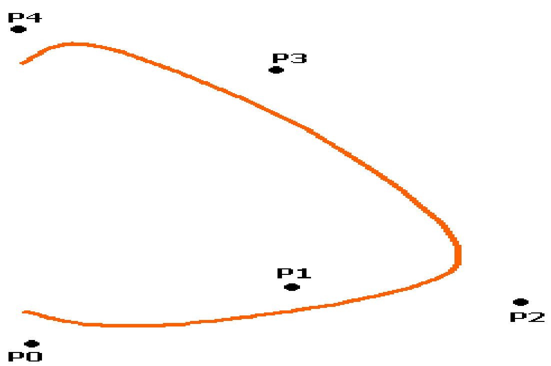
For the development of facial recognition applications to people insisted that uses triangulation method.

It is developed by Peuker, Delaunay triangulation and use. The result is a network of triangles (TIN type structure) perfectly circumscribed circles, which makes the distance between points forming the triangle tops always be minimal. For each triangle is stored coordinates and attributes of the three peaks, topology and slope inclination and direction of the triangle surface [5]. Triangulation works best when data is distributed evenly on the surface to be interpolated. The method is accurate and uses linear interpolation or cubic polynomial. Suitable for large data sets, being fast enough. Allows applications with open source: QGIS (Quantum GIS) with a processing time and SAGA (System for Automated Geoscientific Analyses).

A comparison of the main methods for implementing cubic interpolation was represented by www.geo-spatial.org studies using 101,987 points and 8-core 2.8GHz PC. Thus TIN interpolation using existing QGIS software can process data in a time of 12 seconds and SAGA applications in about 4 seconds.

Experimental methods for the construction of a cubic spline interpolation curve using a basic set of splines. Interpolation curve is obtained as a linear combination (weighted sum) of them. In this case we obtain an interpolation curve on which each checkpoint exerts global influence.

Providing local control on cubic spline interpolation can not be obtained except by renouncing some conditions on the curve. Dropping the requirement that curve to pass through checkpoints, leading to the approximation curves B-spline curves called (Fig. 3).




$$C_i(t) = \frac{1}{6}\begin{bmatrix} t^3 & t^2 & t & 1 \end{bmatrix} * \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} * \begin{bmatrix} P_{i-1} \\ P_i \\ P_{i+1} \\ P_{i+2} \end{bmatrix} \qquad t \in [0,1]$$

Fig. 3. Graphical representation and mathematical spline function

**Detection and recognition of people**

Their detection and recognition is mainly aimed at identifying their human and their location in the image, regardless of the parameters: position, scale, rotation (in the image plane), orientation (rotation out of the plane of the picture), light [11].

The detection is the first step in automatic face recognition systems, the first step in systems "surveillance".

This is an important step in the initialization for tracking (tracking site) face or body in image sequences [26].

**Difficulties**

We identified these difficulties:

• high dimensionality space features: A grayscale image (8 bits / pixel) size 19 × 19 on a drive to 256,361 possible combinations of intensities;

• orientation face confusing rotate out of plane image. This should be clearly defined vertical axis of the head directions: front, profile, half profile and non-vertical head axis and rotation in the image plane / optical axis of the camera;

• conditions image acquisition variables: lighting, camera parameters (sensor gain, image resolution, objective);

• occlusions;

• facial expression of the face is confused with a non-rigid object variable appearance;

• presence / absence of structural elements: glasses, beard, mustache etc.

## 4. EVALUATION DETECTION ALGORITHMS - PARAMETERS

Evaluation of algorithms for detection is achieved by determining the best detection rate (TPR) and false detection rate (FPR).

The rate indicates the percentage of good pixel detection and detected by the algorithm, and the false detection rate indicates the percentage of pixels that do not belong to the detected as being of image.

TPR = NTP / NTP + NFN , (1)
FPR = NFP / NFP + NTN, (2)
where:
NTP is the number of pixels of the face detected correctly (true positives)
NFN is the number of pixels of the face undetected (false negatives)
NFP is the number of pixels of the non - face detected as type face (false positives)
NTN is the number of pixels to the right of the non undetected (true negatives).

When detection algorithm depends on a parameter, it will influence the values of variable detection rates [15].

Algorithm characterization can be performed using the ROC curve (Relative Operating Characteristics), which is in the following figure dependence between FPR TPR AND variation in the parameter algorithm [6,7,19]

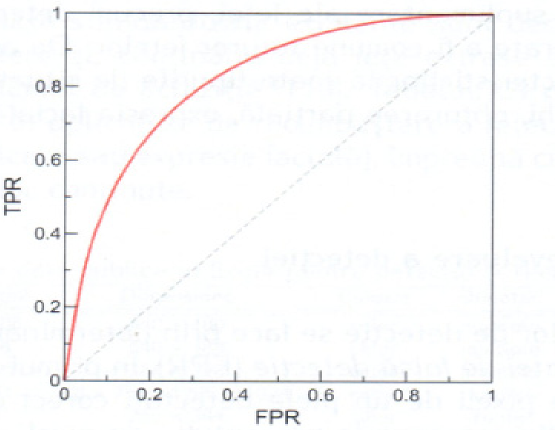



Fig. 4. ROC curve (Relative Operating Characteristics)

Another parameter evaluated is the percentage of the pixel detection of facial skin (SDR) is the number of pixels reaportul skin of the face detected NTP and the total number of pixels in the image N skin skin [20, 21, 22].

SDR = NTP / N skins

The objectives of the work were:
Identification of problems related to their detection
• Locating and - determining the position of a single face in an image
• Detection of facial component elements - the presence and location: eyes, eyebrows, nose / nostrils, mouth, lips, ears etc.
• Recognition / their identification
• Recognition of facial expression
Another concern may be human posture estimation and tracking its

And detection based on color and matching templates in conjunction with the method of detection and tracking eye gaze direction.

Detection and tracking eye gaze direction has been described in reference [8], [9]

## 5. ANALYSIS OF GAZE DIRECTION

Obtaining the 2 eyes images based on region features antopomorfice supposed eyes must have 1/8 of the total height height and width of the face 1/5 of the total width of the face, and the existence of two sub-images containing the eyes of image with the highest resolution (level 0).

The imagery size depends on the scale at which found scaling fixed size (60x80), the pixels by interpolation resulting a bi-linear front [23,24].

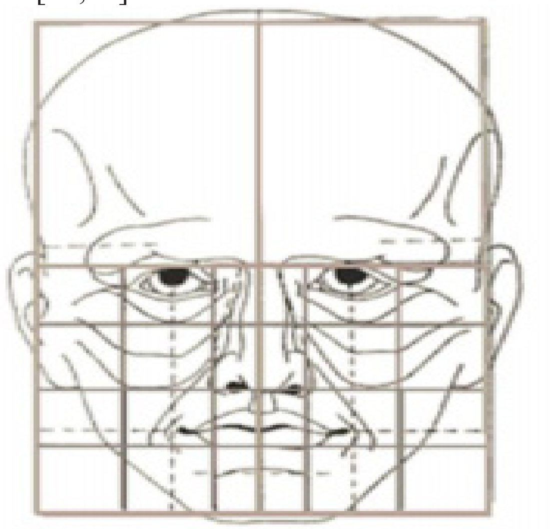


Fig. 5. Detection of the centroid of the analyzed elements located on map

Eye image stabilization stage is performed for detection and tracking is not sufficiently precise for movements of the head of a few pixels. This means the difference between successive frames to create binary image motion and the calculation of moments of order 1 (center of mass).Centroid points results are used to estimate the location of the eyes in the face image or a good accuracy for low-resolution images) [25].

**5.1. Comparison between left and right eye**

The left eye and right eye are compared to determine where the user looks:

They are analyzed: the left eye image is made] and lower the mirror image of the right eye.

Thus, if the user directly to the camera will look the difference is small.

If the user is looking to the left, then put the eye in the mirror will seem like the right look and the difference is obvious.

Further analyzes of intensity differences between right and left eye image reflected and design (summation) to measure their vertical line of vision [25].

**5.2. Measuring the line of vision.** Gaze detection step involves right eye left eye, determining if any of eye movement and direction of movement.

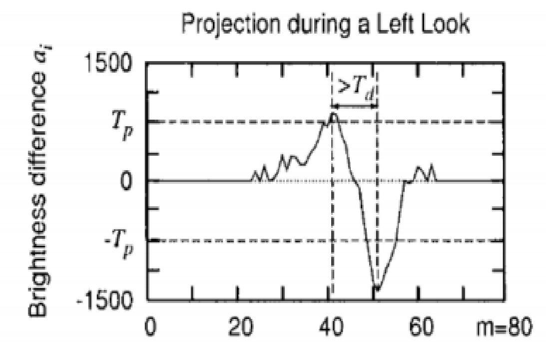



Fig. 6. left eye gaze detection

$$a_i = \sum_{j=1}^{n} (I_r(i,j) - I_\ell(m-i,j)) \quad , \quad (3)$$

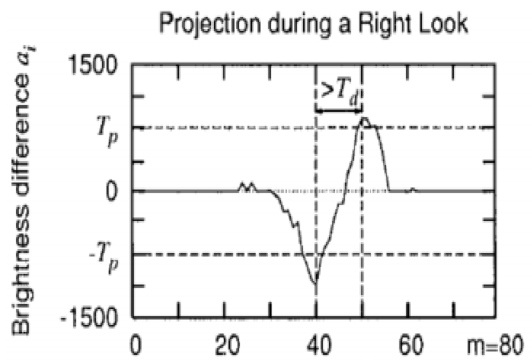



Fig. 7. right eye gaze detection

$$a_{\min} = \min_{i=\{1,\dots,m\}} (a_i) \qquad a_{\max} = \max_{i=\{1,\dots,m\}} (a_i)$$
$$i_{\min} = \arg\min_{i=\{1,\dots,m\}} (a_i) \qquad i_{\max} = \arg\max_{i=\{1,\dots,m\}} (a_i) \quad , \quad (4)$$

There are eye movement:

$$a_{\max} > T_p \qquad a_{\min} < -T_p \quad , \quad (5)$$

**5.3. Examples of location analysis and line of vision.** Analysis of gaze direction is a modern method described in [25,18] ] and is based on the comparative study of eye movements result to certain directions.

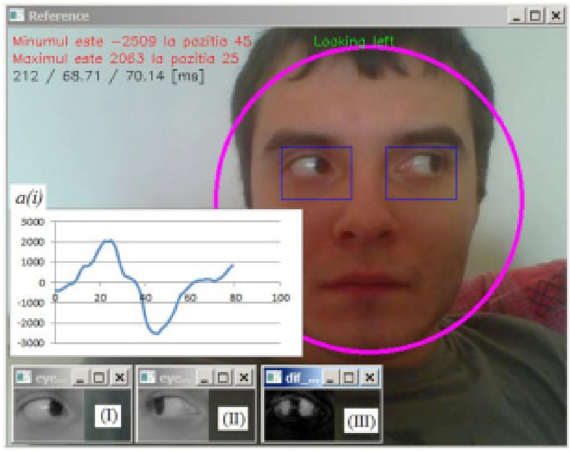



Fig. 8. Illustration left gaze detection results [25]

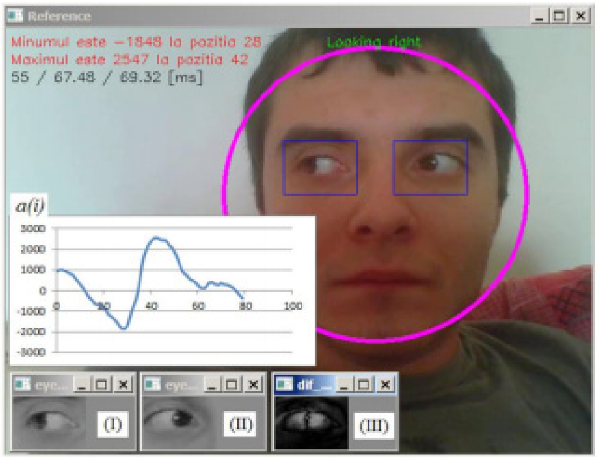



Fig. 9. Illustration of gaze detection results right [25]

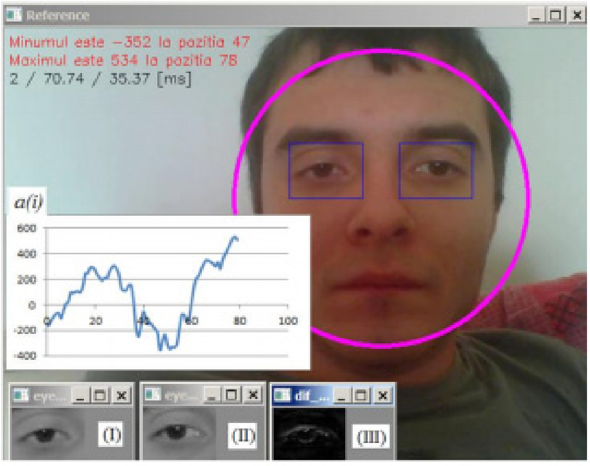



Fig. 10. Illustration of the eye detection results by the center [25]

The algorithm of the location of the pupil

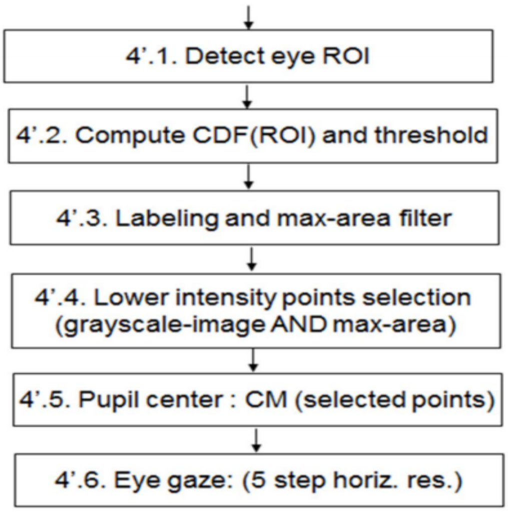



Fig. 11. Block diagram of the pupil localization algorithm

**5.4. Estimating line of vision.** Estimation of the application made personal line of vision involves two main steps:

detection and face tracking and eye direction detection [16,17].

1. Face Detection was performed by the method Viola Jones and OpenCV

2. Detection eye position (Viola Jones) required validation features antropomorfice.şi initialization sablonlui eye.

3. Face tracking was done by tracking the template matching (MatchTemplate / OpenCV)

4. Detection and tracking pupil

Alternative Step 3: CAMSHIFT / OpenCV

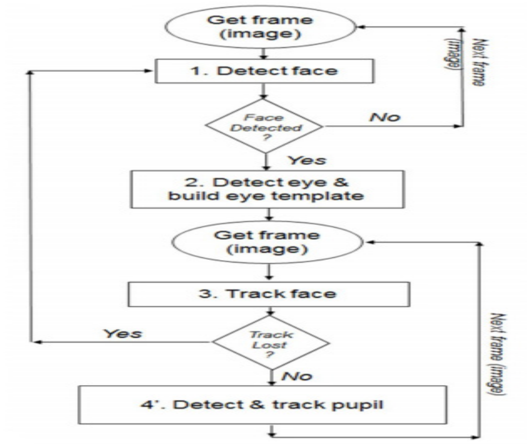



Fig. 12. Scheme drive centroid algorithm for detecting gaze

The algorithm itself. Specific algorithm used in the application is using centroid gaze detection and is described by the following equations, where S is the threshold used to discriminate pupil.

$$X = \sum_{j=1}^{m}\sum_{i=1}^{n} \mu_{ij} x_i \Big/ \sum_{j=1}^{m}\sum_{i=1}^{n} \mu_{ij}, \quad Y = \sum_{j=1}^{m}\sum_{i=1}^{n} \mu_{ij} y_i \Big/ \sum_{j=1}^{m}\sum_{i=1}^{n} \mu_{ij}$$

$$\mu_{ij} = -\mu_{ji} = \begin{cases} 0, & pentru \quad 0 \le \mu < S \\ 1, & pentru \quad S \le \mu < 255 \end{cases}, \quad (6)$$

**5.5. Description of the experiment.**

The application was made from library HAAR classifiers implemented using cubic interpolation technology through predefined functions dumps.

The program runs independently and requires the installation of Microsoft Visual Studio 2013 programming language being developed in C Sharp.

Main considerations underlying its choice was very fast processing speed, the real-time and accessible menu operation / programming [12,13,14]

Programming steps:

1. Declare all variables, objects and image vectors

-definition type font

-definition images after detection results and therefore to be registered in the database

-generating one vector with all images added

-generating one vector with labeling subjects

2. Charging classifier for face detection and eye front type Haar Cascade
-loadind existing faces and labeling each of them
- Capture initialization room (open room)
- Initialization counter drive girls
- Getting a gray frame capture device (camera)
- Initialization detector Emgu facial image processing
3. Define the action for each element detected
4. Redimensiunea detected face image as a comparison to the same scale forced test image using cubic interpolation.
5.Obtain the current capture device
6. Displaying the faces, processed and recognized

## 6. DATABASE

The database is personal created and is described in reference [10].

Fig. 13. Selection of photos from the database used

Most public databases seek recognition as a database containing personal realized that the background image is recognizable and uniform. The images have dimensions of 90x120 pixels.

Field's face rotation angle to the direction of sight is ± 90 degrees and the upper part of the face is partially obstructed by a percentage of up 40% while maintaining axial symmetry elements of the image. Base color images containing personal data people of different races, genders, ages, lighting conditions, background and context percent body skin visible, capturing more emotional and rotation / head covering. The context in which images can be found is varied, before being bounded by the body clothing, glasses, etc.

In this situation recognition resumed to detect skin regions. Thus, it is necessary to use a skin detection algorithm in addition to color information to use additional features such as face detection eyes, mouth or other common elements.

Matters and invariance characteristics in all kinds of situations in which can be found before (its rotation at an angle, facial expression, filling)

## 7. THE RESULTS OF THE EXPERIMENT

Training database containing 12 images of 46 subjects selected by the method of PCA and cubic interpolation used pupil centroid classifier for detection / recognition of gaze direction in conjunction with HAAR-LIKE classifiers.

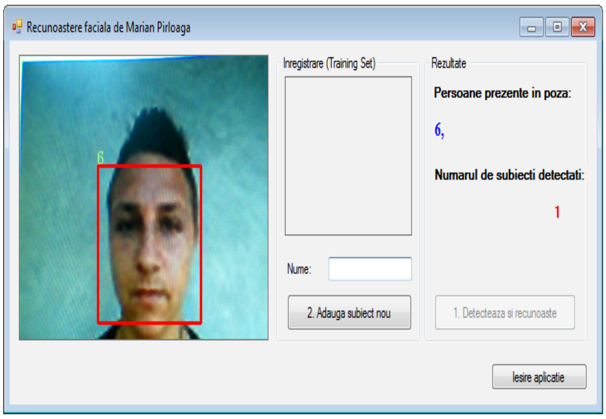



Fig. 14. Screen capture of a person recognized label database

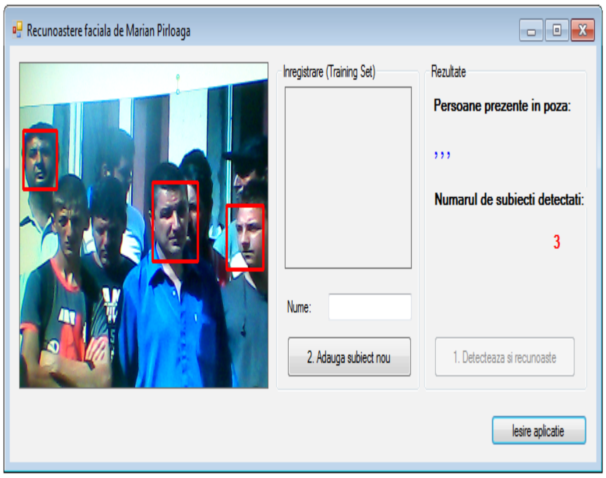



Fig. 15.Captura screen on the recognition of three subjects from the database

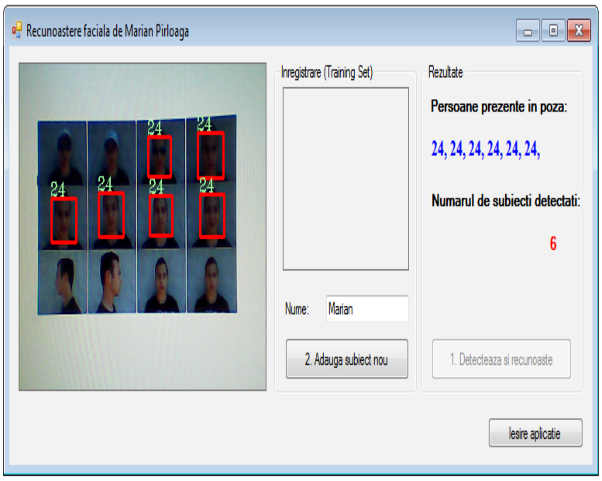



Fig. 16. Screenshot of subject No. 24 database facial recognized in 6 states: glasses, frowning / angry, sad, surprised, joyful. Light: semi-darkness

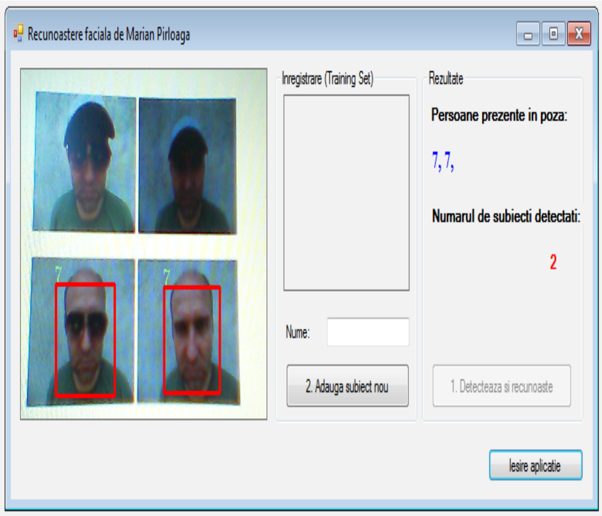



Fig. 17. Screenshot 7 of subject database facial recognized in 6 states: glasses, frowning

## 8. CONCLUSIONS ON IMAGE PROCESSING FOR FACE RECOGNITION

Applied research aimed at obtaining software for real-time recognition of individuals or crowds busy implementing an algorithm together with the most advanced method recognized by Viola Jones.

We experienced AdaBoost algorithm implementing methods, HAAR-LIKE, and HAAR-LIKE staff in conjunction with an algorithm for recognizing pupil and line of vision, proposed in several applications such as distributed systems [13] opposite the traditional methods and a method The proposed staff.

Table 1. Results summary of performances for each experiment

| Indicatory | Distributed Information Systems | AdaBoost Classifier | Classifiers HAAR-LIKE | HAAR-LIKE + classifier classifiers for recognizing pupil |
|---|---|---|---|---|
| False acceptance rate(%) | 45.16 | 49.05 | 56.75 | over 95.42 |
| False rejection rate(%) | 33.80 | 28.50 | 24.98 | maximum 15.08 |
| Processing Time (sec.) | 130 | real time | real time | real time |
| Face recognition for rotation (degrees) | without | 60 | 45 | 45 |
| Face recognition and emotional states covered above | no | no | yes | yes |

1.Method HAAR-LIKE implementing classifiers and a classifier for recognizing the pupil respective line of vision is most applicable for military applications.

This allows a rate of more than 15% false recognition, a recognition rate over 95%, in real time, to a rotation of the subject's face up to 45 degrees, and the recognition of the upper face cover or of the emotional state.

2.Using classifiers HAAR-LIKE processing time remains the same, but the recognition rate is decreased to 56.75%, and the false recognition ncreases to 24.98%. The method allows face recognition when the top is closed, emotional states, but does not allow facial recognition rotated more than 45 degrees.

3.The application allows detection using AdaBoost their higher ungiuri oriented to 60 degrees from the normal position, image acquisition front. Instead false recognition rate of 28.50% high and the recognition is only 49.05%.

The application does not allow the recognition of the upper face covered or emotional states.

4.The results of adopting the method of distributed systems shows that there is great confusion recognition between classes of people, and not make a very good separation between data acquisition and processing in humans, animals or objects in the background.

Best processing time is 130 seconds.

The application does not allow the implementation of the portable computer terminals and interconnected systems assume that in military terms is difficult.

False recognition rate of 33.80% is very high.

5.Using implementation in Microsoft Visual Studio, detection and recognition is performed in real time, there are no delays due eg mathematical processing. in Matlab.

6.The method performed by the conjunction of two classifiers allows recognizing the faces of people in crowds crowded so backlit normal, uniform and on a rough background, surrounded by objects in different lighting.

It allows the recognition of six emotional states associated with the subject, including its recognition wearing glasses, without making confusion with other classes of subjects.

7.All computer applications allow processing of images stored as .jpg, .png or .bmp and fixed video images in real time provided by a video camera.

8.Comparison and practical results lead to software recommendation implies classifiers HAAR-LIKE conjunction with a classifier for recognizing pupil and line of vision, surveillance for military applications involving the detection and recognition of people in crowds or crowded, sporting events, cultural religious, detection of persons under confinement at the border, and pursued the suspects subject to military or police action.

9.Image processing is a complex and very dynamic, with numerous applications in various military.

Further optimization of the application may allow the extraction of useful information from the image and improve the extraction and analysis.

10.The application was tested in applications optimized operative to detect and recognize persons who are the subject for gendarmerie and police missions in crowded crowds - giving good results in terms of operational.

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