The systems for persons' identification and verification on the basis of face correlation recognition

Veacheslav Perju, David Casasent, Andrei Galben, Octavian Ciubotaru

Veacheslav L. Perju, David P. Casasent, Andrei I. Galben, Octavian P. Ciubotaru, "The systems for persons' identification and verification on the basis of face correlation recognition," Proc. SPIE 6245, Optical Pattern Recognition XVII, 62450Q (17 April 2006); doi: 10.1117/12.664826

SPIE.

Event: Defense and Security Symposium, 2006, Orlando (Kissimmee), Florida, United States

The systems for persons' identification and verification on the basis of face correlation recognition

Veacheslav L.Perju[1,3], David P. Casasent[2], Andrei I. Galben[3], Octavian P. Ciubotaru[1]

[1]Technical University of Moldova, Department of Informatization, Stefan Mare Av., 168, Chisinau, MD-2012, Republic of Moldova, Tel:(373) 79431245; E-mail: perju@adm.utm.md
[2]Carnegie Mellon University, Department of Electrical and Computer Engineering, Pittsburgh, PA 15213 USA, Tel: 412-268-2464, E-mail: casasent@ece.cmu.edu
[3]Free University of Moldova, Vlaicu Pircalab Str., 52, Chisinau, MD-2004, Republic of Moldova, Tel:(37322) 205920; E-mail: galben@ulim.md

ABSTRACT

In the article it is presented a PC based system for persons' identification and verification on the basis of face correlation recognition. There are described the structure and the functions, the software, the interfaces, the options of image processing. There are presented the investigation results of the influence of the noise, rotation and scale of the input images on the identification process. There are calculated the data concerning the recognition time for the images of different resolution. In order to increase the system's productivity it is proposed to use an optical-electronic system.

Keywords: correlation, recognition, face, information system, identification, verification

1. INTRODUCTION

In terrorism and organized crime combating one of the important problems becomes the identification and verification of persons[1]. In artcicles[2,3] we used the correlation method for persons identification and verification on the basis of the fingerprints. We showed the high robustness of the correlation method in the conditions of the change of the scale and angular orientation of the input images, of the surface reducing etc.

In the present article we use the correlation algorithm for persons' recognition on the basis of faces. In chapter 2 it is described a PC based information system for persons' identification and verification. There are presented the structure and the functions of the system, the software, the interfaces, the options of image processing. The elaborated system permits to introduce images of variable resolution using different kinds of the sensors such as TV camera, Web camera, digital camera or scanner. The system permits to create and modify the personal records in data base, to realize the searching operations.

Optical Pattern Recognition XVII, edited by David P. Casasent, Tien-Hsin Chao,
Proc. of SPIE Vol. 6245, 62450Q, (2006) · 0277-786X/06/$15 · doi: 10.1117/12.664826

In chapter 3 there are presented the investigation results of influences of the noise, rotation and scale of the images on the identification results. The data show that the noise with the probability P=0.01, the change of the rotation with the angle on 0.1 degree and the scale with 1.5% of the input images lead to the correlation function maximum's decrease with 60%. To increase the reliability of persons recognition it was analyzed the correlation algorithm based on the image transformation to the polar logarithmic system of coordinates. The experiments showed the stability in faces recognition at rotation and scale changes of the input images in this case.

In chapter 4 there are presented the data concerning the recognition time for the images of different resolution. In order to increase the system's productivity it is proposed to utilize an optical-electronic system.

2. INFORMATION SYSTEM FOR PERSONS' IDENTIFICATION ON THE BASIS OF THE FACES

2.1. The structure of the system

The structure of the information system for persons' identification on the basis of the faces (ISPIF) is presented in the fig 1. The system is realized on the basis of the standard PC.

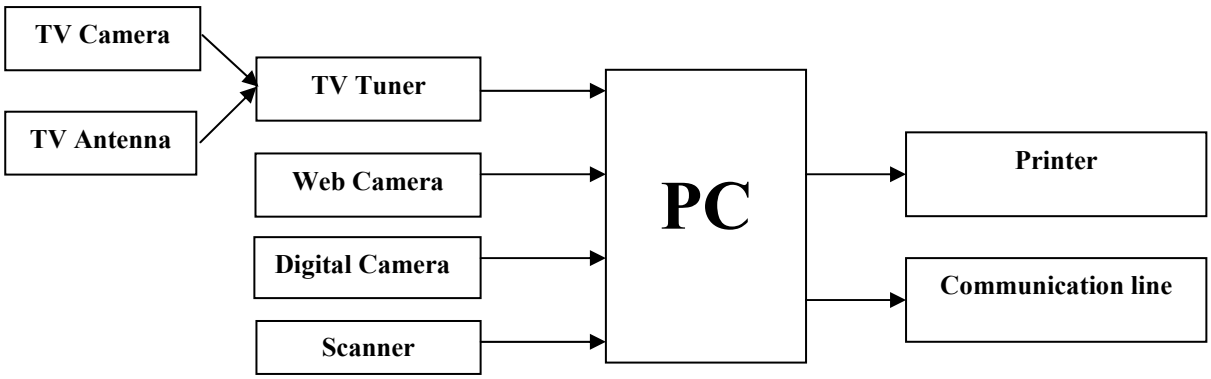

Figure 1. The structure of the ISPIF

The specialized software was realized on the basis of C++ Builder package of the Borland International Inc. and data base PostgreSQL. The software is encoded in the C++ language using object oriented programming principles.

The functions of ISPIF system are:
1. The images' capture from different devices such as TV Camera, TV antenna, TV Tuner, Scanner, Web Camera, Digital Camera and other devices that support the WDM or TWAIN interfaces.
2. The images' introducing at different resolution;

3. Images processing: translation, rotation, scaling, images' transformation in logarithmic polar coordinates system;
4. Images' centering;
5. The deleting of any section of the image;
6. Person's identification;
7. Person's verification;
8. Advanced searche in the data base;
9. The introduction, deleting, completion of the personal records in the data base;

The ISPIF system can be installed on the PC which supports x486 or more advanced platform, ensured with the SVGA graphical adaptor and Windows 95/98/2000/NT/XP/2003 operational system (using Win32 API platform).

2.2. The software

The main modules of the ISPIF' software are presented in the fig.2.

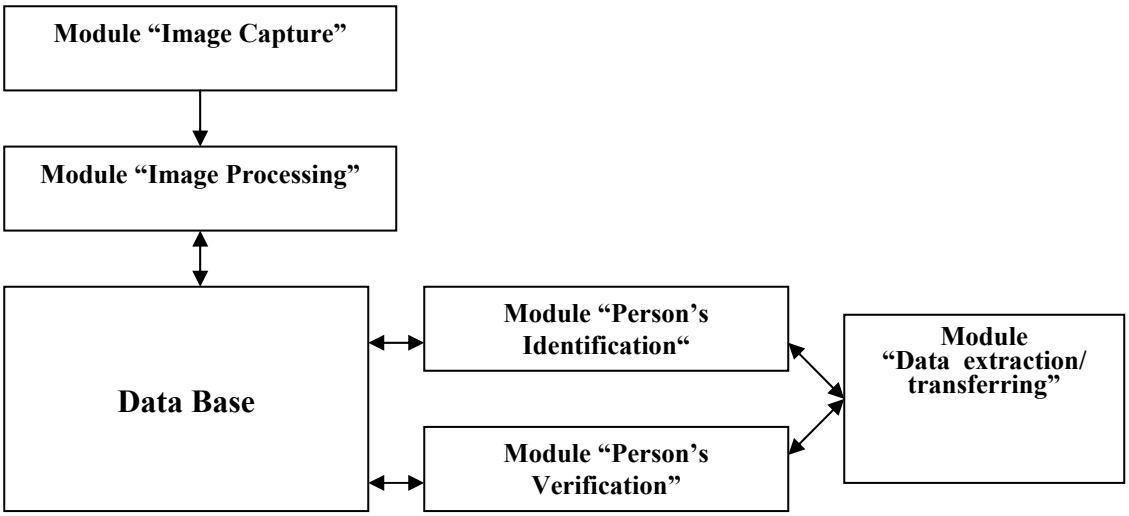

Figure 2. The main module of the ISPIF' software

The "Image Capture" module is used for realization of the image introducing operation from external devices. The "Image Processing" module is used for various operations over the images: scaling, rotation, sections deleting, centering. The "Data Base" module contains the personal records of the persons, including images. This module implies basic operations as inserting, editing, deleting, visualization and searching of information. The searches may be done on the basis of the required parameters. The module "Person's Identification" and "Person's Verification" are the main ones, which recognize the persons on the basis of different algorithms. The module "Data extraction/transferring" realizes the operations of the information output on the printer or in the communication line.

2.3 The system's interface

The main window (fig.3) contains the next options: File, Edit, Capture, Recognition, Data Base, Windows and Help. Some options are described below.

The option and window „Data base/Search"(fig.4). The personal records include different information such as: Name, Home address, Job data, ID etc. The search can be made on some of the data. After the search execution there will appear the list of founded records. If it is necessary to visualize more detailed information it is made a double-click on the record. There are also a group of buttons which simplify the navigation on the list.

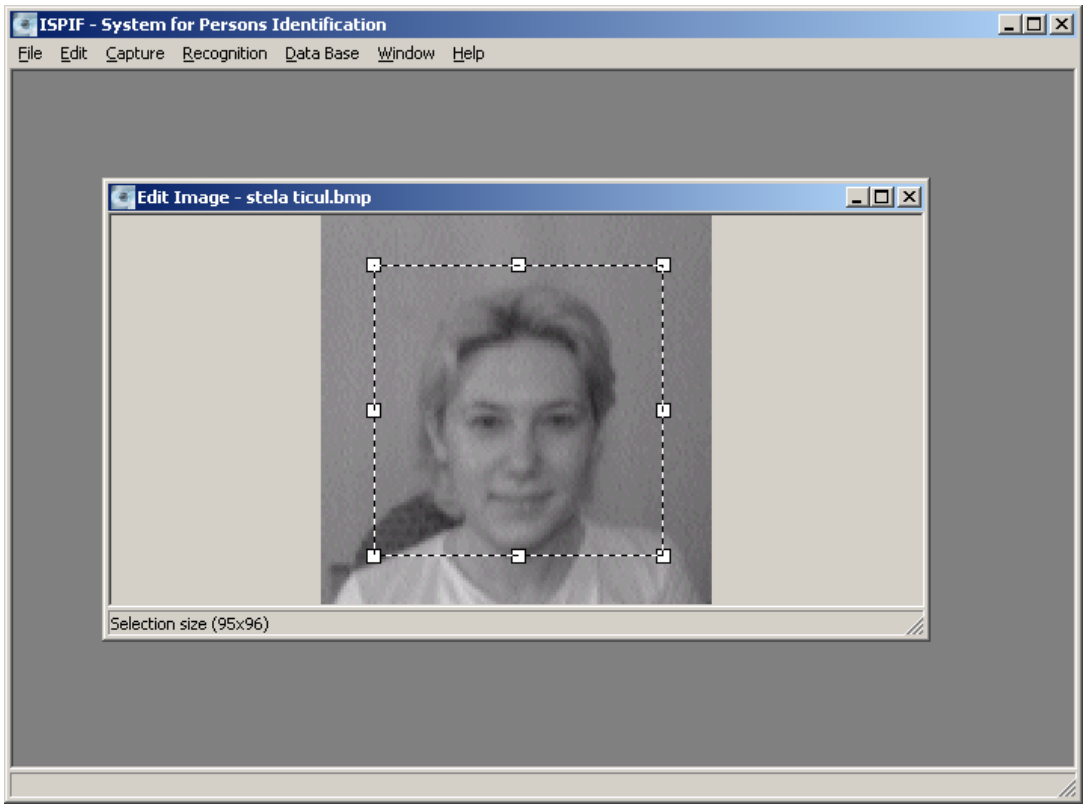

Figure 3. The main window

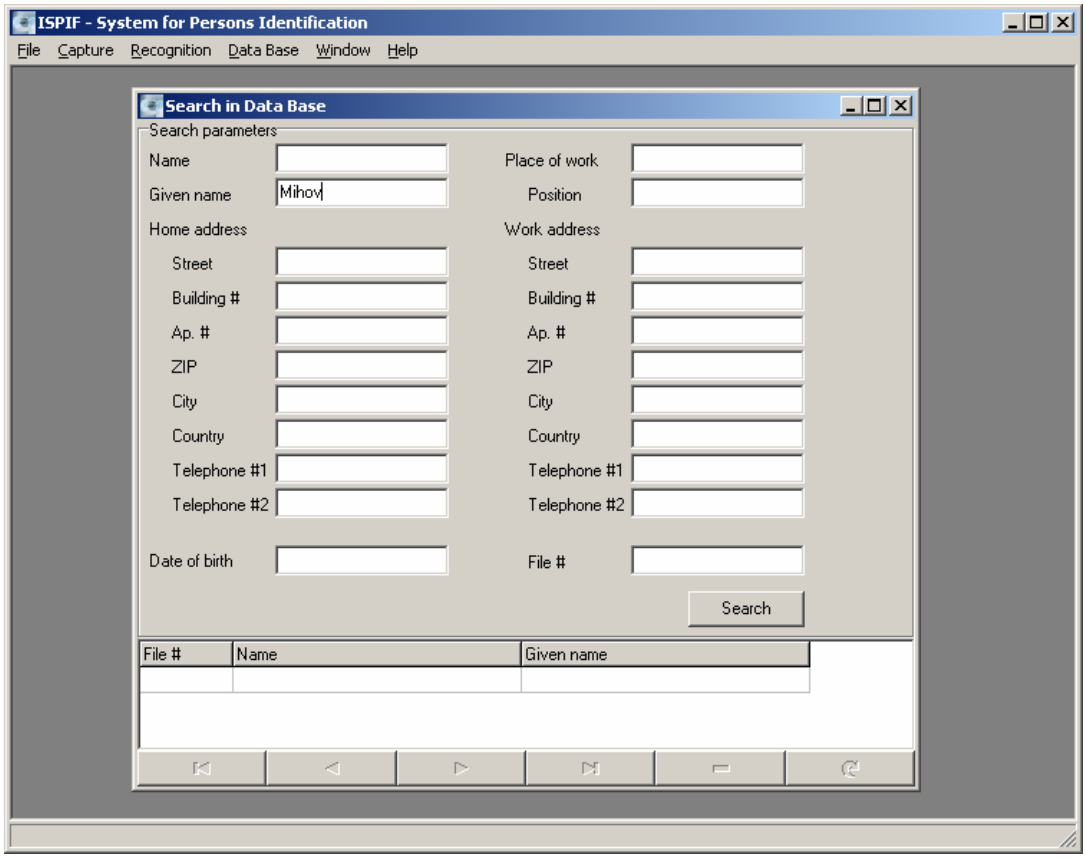

Figure 4. The window „Data base/Search"

The option and window „Persons Identification" (fig.5). In the left side of the window it is specified the image which must be identified. This image can be loaded from the clipboard or from the file. In the top of the window there is a button "Parameters", at the selection of which there appear all the options related to the process of identification, including the algorithm of identification (fig.6):

General Settings/Recognition algorithm/Correlation algorithm;

General settings/Recognition in the base of:

- *Primary image* - recognition will be done on the basis of initial image;
- *Secondary image* - on the basis of the processed image.

Correlation algorithm settings/Filter

- *Amplitude*
- *Phase*
- *Amplitude/Phase*

Algorithm modifications

- *Log-Pol* coordinates - the image is transformed into logarithmic-polar coordinates system;
- *Image centering*.

- *Threshold level* – the establishment of the threshold at the image identification.
- *Resolution* – establishment of the image resolution.

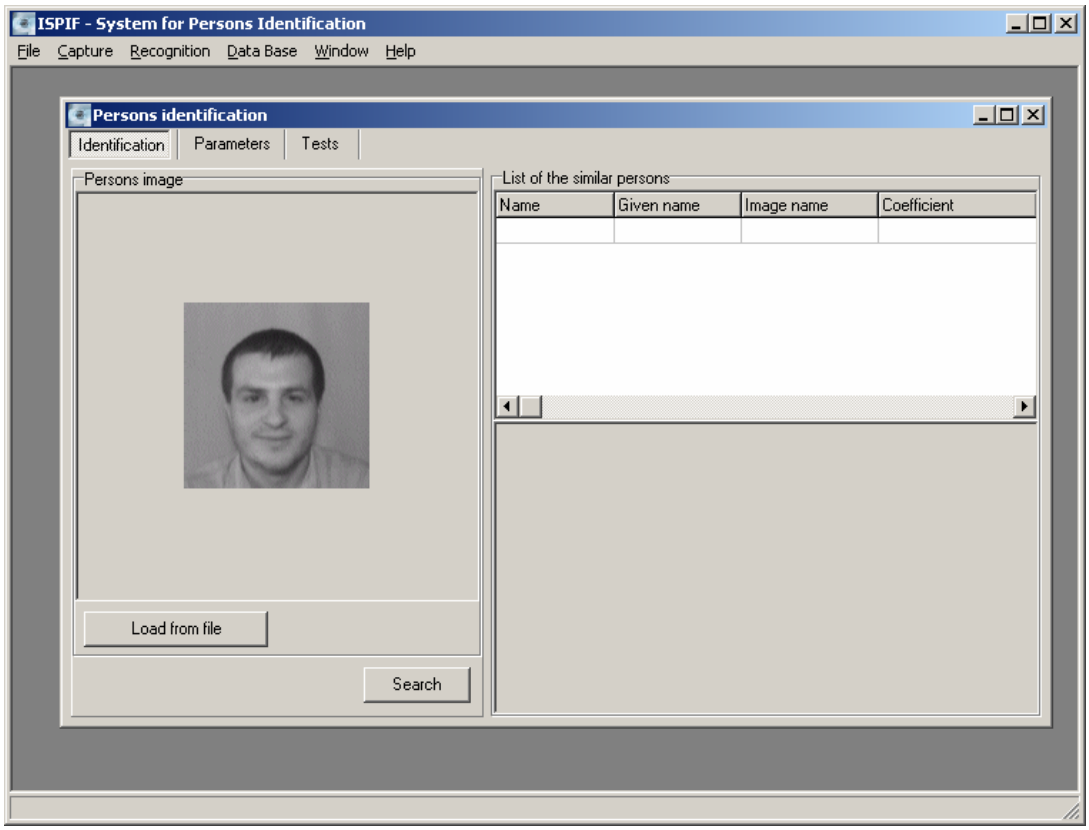

Figure 5. The window „Recognition/Identification”

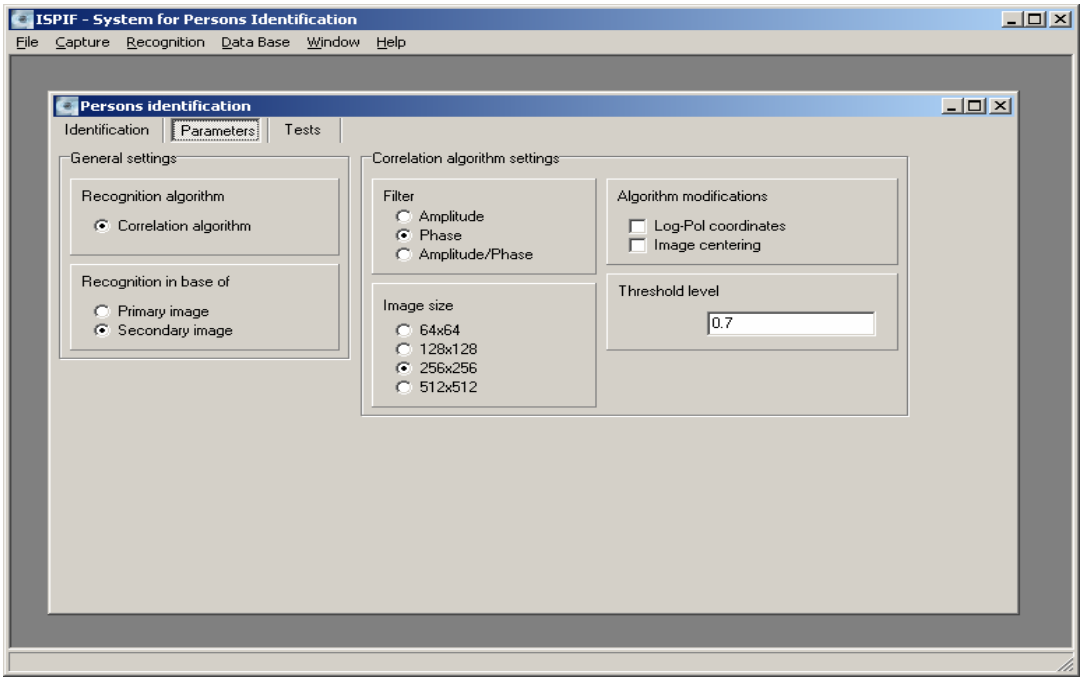

Figure 6. The window „Parameters"

3. FACE RECOGNITION ALGORITHMS

In the experiments were used 2 correlation algorithms for face recognition. The first algorithm is based on the calculation of the correlation function between the image of the unknown face and one of the standard images, presented in Cartesian coordinates system:

$$C(\xi, \eta) = \iint_{-\infty}^{\infty} P(x,y)H^*(x-\xi,y-\eta)dxdy, \qquad (1)$$

where P(x,y) describes the unknown image and H(x,y) is the standard one.

Another algorithm is based on the preliminary transformation of the images into the logarithmic polar coordinates system[4]:

$$C(\xi_1, \eta_1) = \iint_{-\infty}^{\infty} P(x_1,y_1)H^*(x_1-\xi,y_1-\eta)dx_1dy_1, \qquad (2)$$

were $x_1=\text{arctg}(y/x)$ and $y_1=[\ln(x^2+y^2)]/2$

Using these algorithms there were investigated the correlation function in the conditions of the noise influence, change of the angular orientation and scale. These investigations were carried out using the information system IFPIC described in chapter 2. The test images are presented in the figure 7.

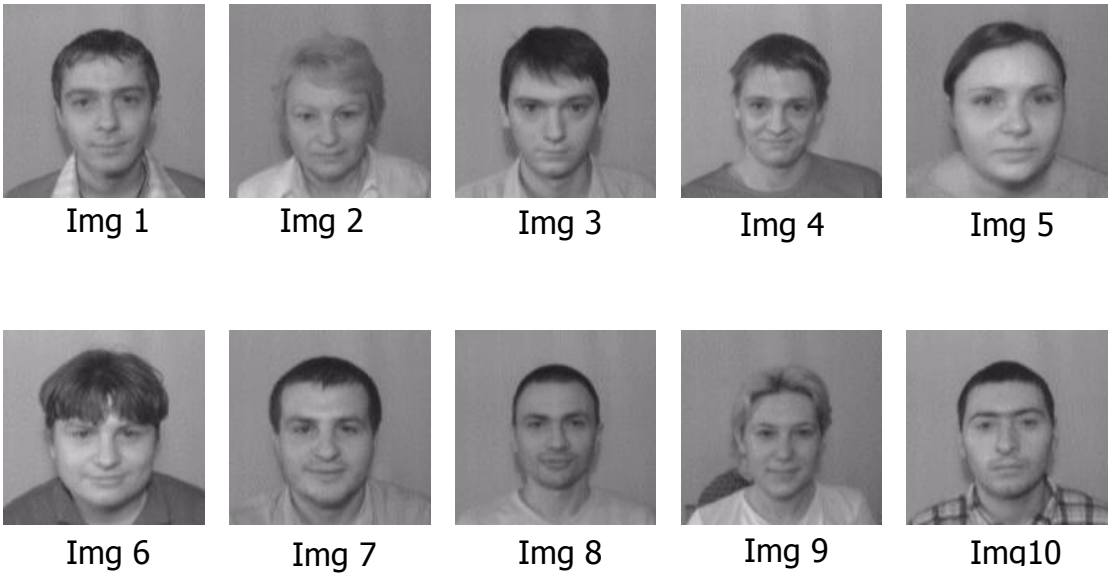

Figure 7. Test images

It was calculated the parameter $C_M = \max\{[C(\xi,\eta)]^2\}$ - the maximal value of the correlation function and parameter K - the relation of the C_M value of the cross-correlation function to auto-correlation function.

At the first step there were established the minimal values of parameters K for test images (fig. 8). These data permitted to determine the image nr.9 as a "critical" image which is characterizing by minimal value of K=0,1. For image nr.9 there were carried out the investigations of the noise influence, change of the scale and angular orientation.

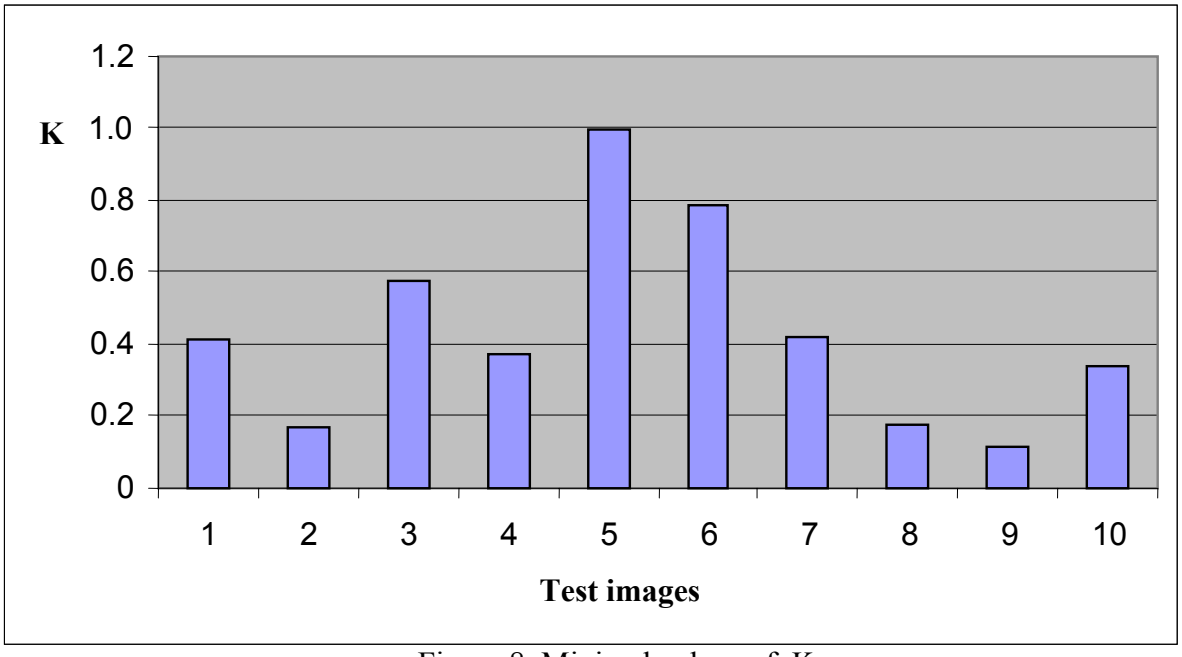

Figure 8. Minimal values of K

In figure 9 are presented the images with different probability P of the additive noise introduction. The results of investigations of the noise's influence on the normalized value C_M are presented in figure 10. From these data it is possible to conclude that noise influence sufficiently on recognition process because at P=0,01 the value of C_M decrease from 1,0 to 0,4.

P=0.01 P=0.03 P=0.05 P=0.07 P=0.09

Figure 9. Images with different probability P of the additive noise introduction

In figures 11 and 12 are presented the data regarding the influence of the image rotation and scale change on the correlation function using both correlation algorithms. The results of investigations shows that at angular orientation change on 0,08 degree and on scale change on 1,5% the normalized value of C_M decrease from 1,0 to 0,6 for the first recognition algorithm. At using of the second algorithm the value of C_M change very insufficiently.

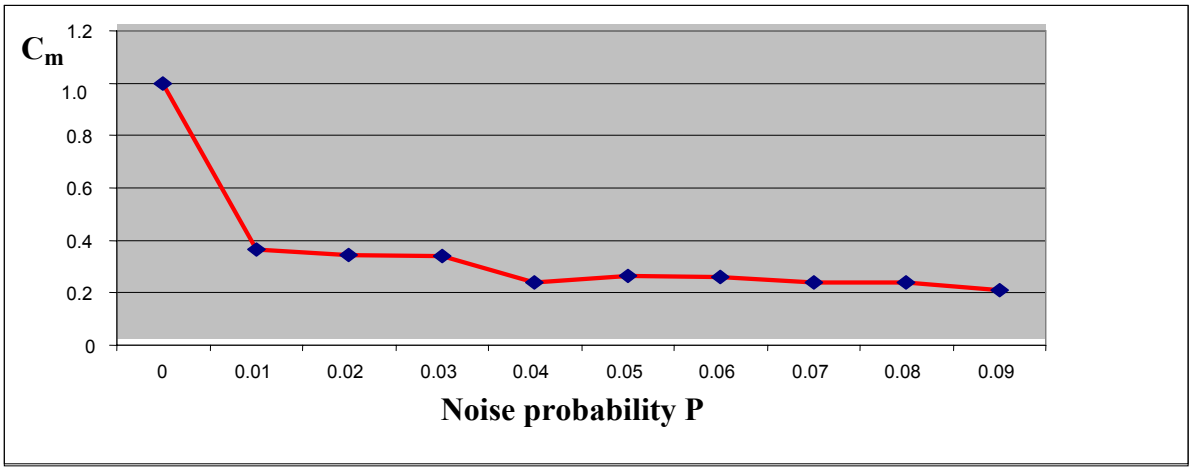

Figure 10. Dependence of C_M from noise probability P

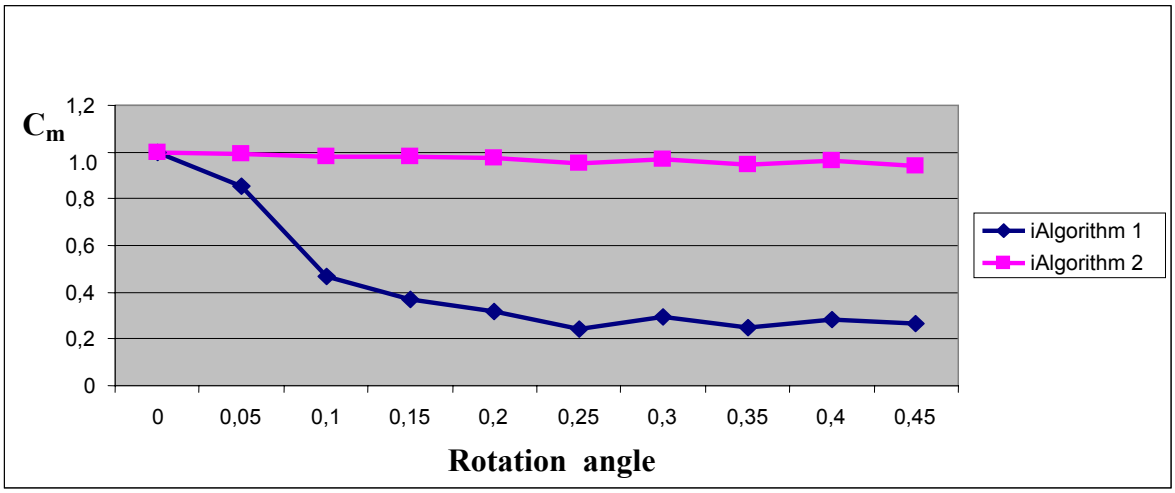

Figure 11. Dependence of C_M from image rotation

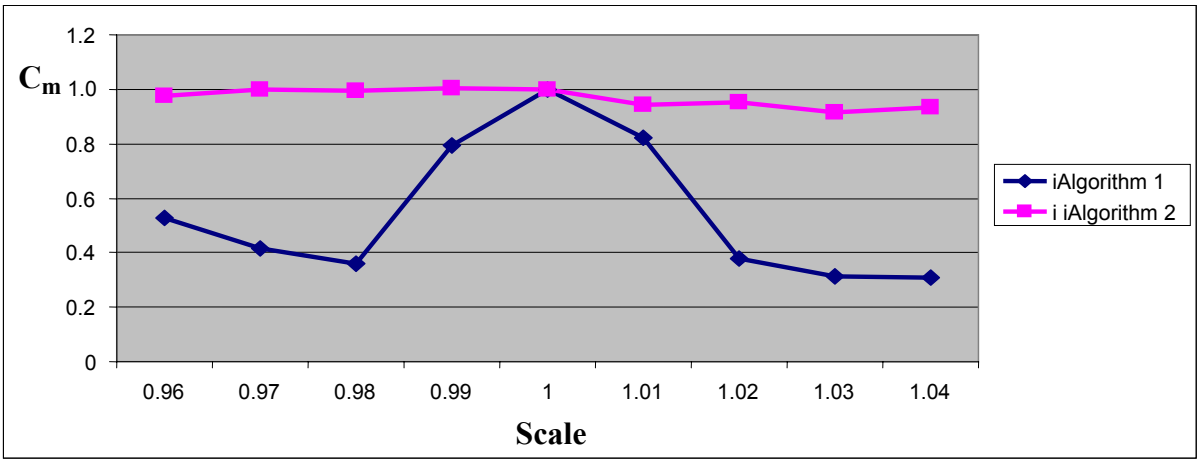

Figure 12. Dependence of C_M from image scale

4. PROCESSING TIME IN THE SYSTEM

It was estimated the recognition time in the system for the images of different resolution. The data presented in figure 13 show that the minimal correlation time is for images of 128x128 pixels and is equal to 0,1sec for processor Intel Celeron 1,7MGh. So, at the elaborated system and used computer of 1,7MGh processor frequency the speed of person's verification will be 10 persons per second.

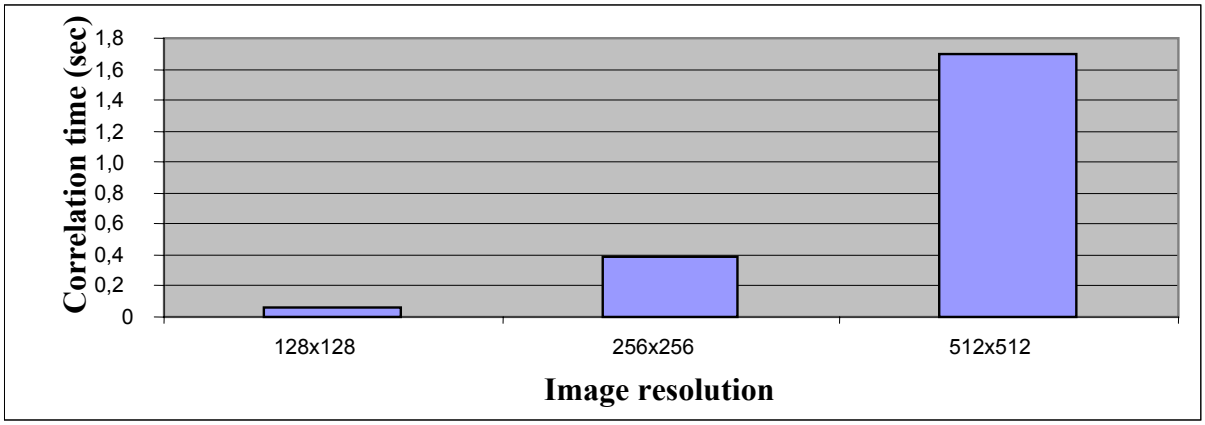

Figure 13. Processing time in dependence from image resolution

In order to increase the speed of persons' recognition can be used an optical electronic system described in article[5] (figure 14). This system can ensure the recognition speed of 5000 persons per sec.

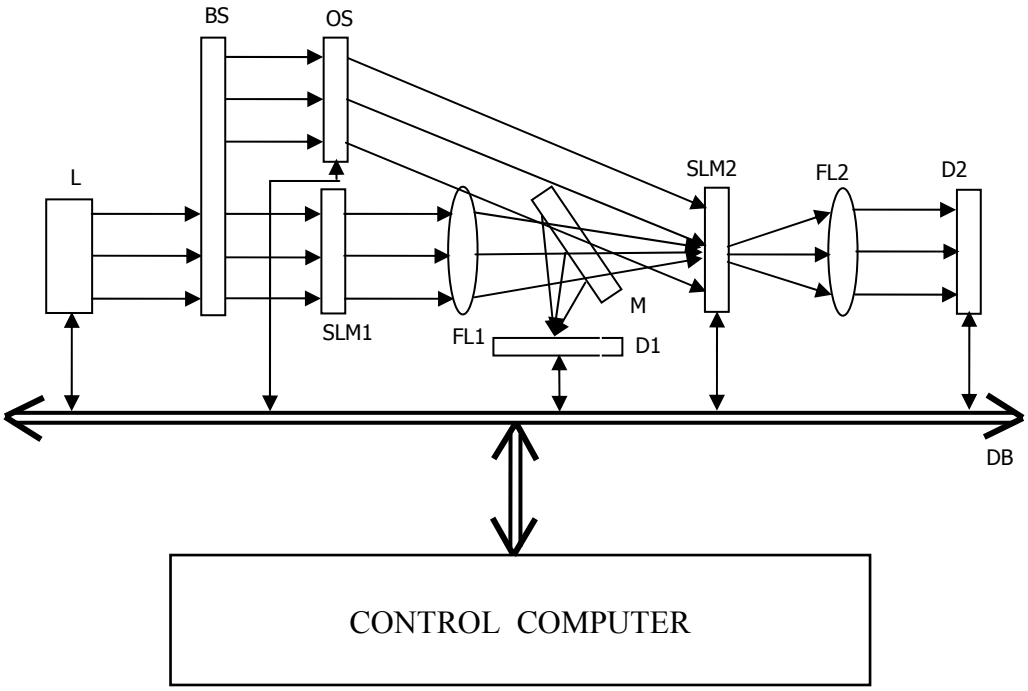

Fig.14. The optical-electronic system: L-laser; BS-Beam Splitter; SLM-Spatial Light Modulator; FL-Fourier Lens; D-Detector; DB-Data Bus

CONCLUZION

1. The elaborated information system permit to recognize the persons on the base of the faces and is characterized by possibility to be utilized on the standard PC, to introduce the images from different sensors such as TV camera, Web camera, digital camera, scanner, permit to carry out the modeling of different algorithms.

2. The carried out investigations permitted to establish the fact that at faces recognition the standard correlation algorithm is very sensitive to changes in angular orientation (not more than 0,05 degree), scale (not more than 1%) and to noise (not more than P=0,005).

3. For avoiding of the rotation and scale influence can be used correlation algorithm based on transformation of the input images into the logarithmic polar coordinates system. To avoid the influence of the noise it is necessary to introduce a supplementary operation of noise cleaning.

4. The investigations of the elaborated system on the PC with processor Intel Celeron 2,3MGh show the possibility to recognize 10 persons per second at image resolution of 128x128 pixels, which in some applications can be enough. To increase the recognition speed can be used more advanced PC or an optical electronic system.

REFERENCES

1. Combating terrorism and its implications for the security sector. T.H.Winkler, A.H.Ebnother, M.B.Hansson, Editors. Elanders Gotab, Vallingby, 2005.

2. Perju V.L., Casasent D.P., Perju V.V., Saranciuc D.I. “Semi spectrum correlation methods for fingerprints recognition”. In Optical Pattern Recognition XIV. David P. Casasent, Tien-Hsin Chao, Editors. Proc. SPIE 5106, p.287-297 (2003).

3. Perju V.L., Casasent D.P., Perju V.V., Saranciuc D.I. “Optical electronic systems for fingerprints recognition”. In Optical Pattern Recognition XIV. David P. Casasent, Tien-Hsin Chao, Editors. Proc. SPIE 5106, p.298-308 (2003).

4. Casasent D. “Optical Pattern Recognition for Computer Vision”./ In: Handbook of Pattern Recognition and Computer Vision (2nd Edition). C.H. Chen, L.F.Pau and P.S.P. Wang, Eds. pp. 869-890 (1998).

5. Perju V.L., Casasent D. P., Perju V.V, Saranciuc D.I. “Perspective optical-electronic technologies for persons identification and verification on the basis of the fingerprints”. In Information Technologies-2004. A.Andries, V.Perju, Editors. Proc. SPIE 5822, p.21-34 (2005).