Computer Correlative Method For Biomedical Image Processing On Base Optoelectronic "Eye-Processor" Device

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***Abstract*-- We present a novel specified method and its application for pattern analysis. Architecture of optoelectronic device of "eye-processor" type has been improved. In paper the device is designed for transformation and storing of images applying automatic processing of images by means of introduction of blocks to carry out the comparison of reference image of the object and image of recognized object and background. It is very important for image processing, especially in real time in dynamic biomedical systems.**

***Index Term*– optoelectronic, eye-processor, biomedical Image.**

I. INTRODUCTION

A great number of publications, dedicated to this problem, underlines, on one hand, practical need in such methods, and on the other hand — it shows the lack of generalized and universal methods of processing of large arrays of biomedical information (N.A.Agadzhanian, J.C.Aschoff, L.Glass, V.P Kojemiako, V.P.Skarbnikov, N.A.Korenevskiy, A.A.Patilov, K.V.Sudakiv, O.P.Rotshtein, A.N.Prodeus, E.N.Zakhrabova and others.) [1,2,3]

Already known methods, developed and applied for engineering purposes are unfit for solution of medical and biomedical problems due to considerably greater complexity of the object under investigation and boundary conditions or require considerable computing capacity that does not correspond to expected results.

One of the most promising areas of application of optoelectronic matrix systems is the creation of flat operational screens for parallel registration and representation of biomedical images [2]. The advantages of application of optoelectronic base for hardware realization of optic neurocomputers (ON) where light is the carrier of information have been proved. It permits to elaborate 2D (dimensional) space structures 2048×2048 pixels. In this case light beams are intersected in 3D (dimensional) space with interaction. Optoelectronic element base (LCLV, LCTV, FLC, SLM, SLM, photorefractive crystals) allows to carry out in parallel operations of addition, subtraction and non-linear transformation over two-dimensional images [2,3,4,6].

The analysis of optoelectronic element base shows its high efficiency for construction of means intended for transformation and processing of biomedical images and signals due to such features as multifunctionality, parallel process of information processing and self-control, which permit to increase fast-acting while solving mathematical problems dealing with processing of images of large dimensions, recognition of images (systems of image recognition that are invariant regarding shift, rotation and scale of input image and are able to recognize objects irrespective of background and angle of observation or of configuration of the object; density of image, highlight of the most bright details, elimination of background noise and details that do not contain useful information) [2].

II. METHODOLOGY OF THE STUDY

In paper is considered the method of correlative-extremum analysis of coordinates for determination in order to measure the value of information signs, that are in current biomedical image, being processed $F(\vec{\tau})$ which suppose to apply in optoelectronic devices

$$F(\vec{\tau}) = F_n(\vec{\tau}) + O(\vec{\tau}_1 + \vec{\tau}_{shift}) \qquad (1)$$

where $F(\vec{\tau})$ - array of readings of currently processed image (PI); $\vec{\tau}$ — vector of readings coordinates, that belong to PI; $F_n(\vec{\tau})$ — array of readings of PI background; $O(\vec{\tau}_1 + \vec{\tau}_{shift})$ — array of reading of object, contained in PI ; $\vec{\tau}_1$ — vector of readings coordinates in the system of coordinates of the object; $\vec{\tau}_{shift}$ — shift of the object relatively the background in PI.

In order to realize cross- correlation of sets of generalized contour preparations of reference image of the object g(x,y) and image of recognized object and background f(x,y) the diagram of optoelectronic correlator is suggested (Fig.1)

Block-diagram of optoelectronic correlator comprises conversion modules 1, 2, module for measuring of geometric dimensions 3, centering module 4, correlation

modules 5 and multiplication module 6. Conversion modules 1,2 perform image conversion f(x,y) and g(x,y) correspondingly forming sets with s_x generalized contour preparations of the first type $\{F_{u\varepsilon\beta}\}$ and $\{F_{g\varepsilon\beta}\}$ (ε = 1, 2, ..., S; b = 1, 2,...,x) of corresponding images.

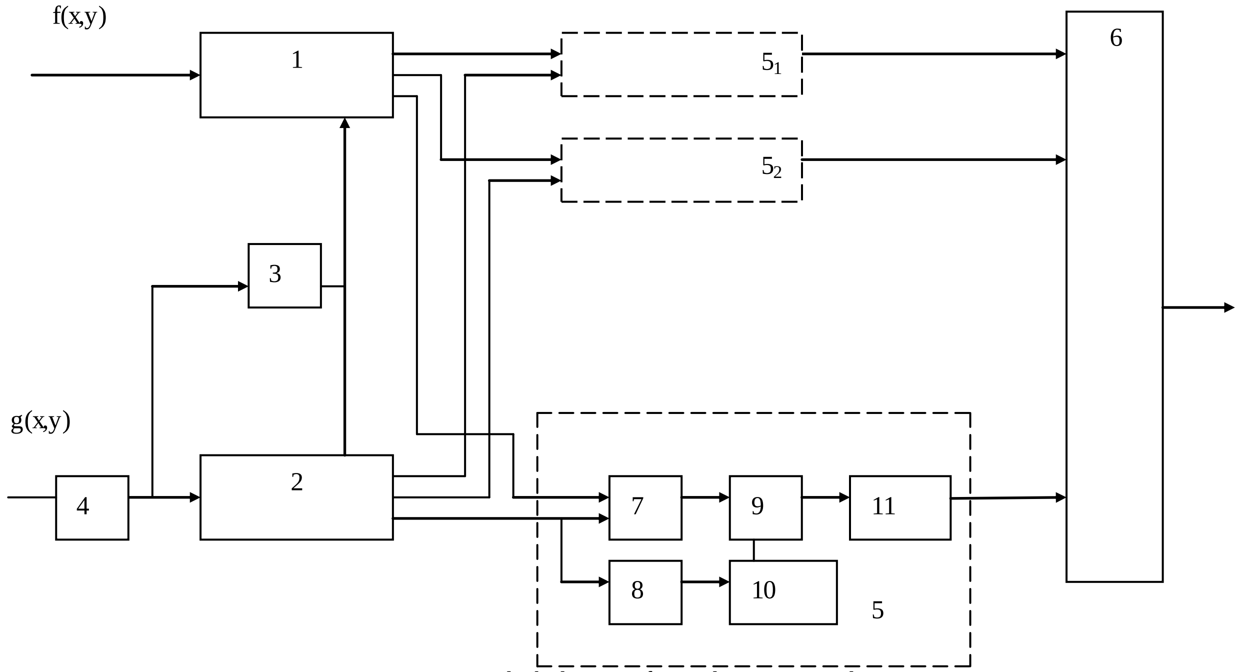

Fig. 1. Block-diagram of optoelectronic correlator

Centering module 4 shifts the object to the connection of geometric centers of the object and image field g(x,y). Module of dimension measuring 3 measures maximal dimensions S_x and S_y of the object in directions of digitization, that determine number S of groups of generalized contour preparations S=max (S_x, S_y). Each correlative module $5_{\varepsilon\beta}$ (ε=1,2,...,s; β=I,2,....,x) comprises unit of cross correlation 7, unit of autocorrelation 8, comparison circuit 9, maximum recorder 10, shift unit 11. Units 8,7 of correlative module $5_{\varepsilon\beta}$ perform cross-correlation of generalized contour preparation $F_{u\varepsilon\beta}$ and $F_{e\varepsilon\beta}$ and autocorrelation of generalized contour reference $F_{e\varepsilon\beta}$ correspondingly. Recorder 10 finds out maximal value of autocorrelation $U_{a\varepsilon\beta max}$ records its value. Unit 9 performs comparison of values of 2D (two dimensional) signal of cross- correlation $Ua_{\varepsilon\beta}max$ with limiting value g $U_{a\varepsilon\beta max}$ (g< 1-coefficient) and forms two-dimensional signal $U_{\varepsilon\beta}$ with level "1" for region of values of signal $U_{b\varepsilon\beta}$>g $U_{a\varepsilon\beta max}$ and with level "0" for region of signal $U_{b\varepsilon\beta}$<g $U_{a\varepsilon\beta max}$. values. Shift unit 11 performs fixed shifting of $U_{\varepsilon s}$ signal on digits along directions of digitization in order to compensate contour preparation of ε^{th} group while its formation. Multiplexing module 6 performs logic conjunction of two-dimensional signals $U_{\varepsilon\beta зад}$ (ε=1,2,..., S ; β =1,2,...,x), obtaining two-dimensional two-level signal U_c. The centre f signal U_c region with level "1" corresponds to the centre of recognized object.

III. REALIZATION

Analyses practical realization of optoelectronic means intended for processing of biomedical images and signals. The developed method of eye-processor type of processing can be used both in biomedical systems and in systems of technical vision used for image (pattern) recognition.

Structural diagram of optoelectronic device is realized in the following way (Fig.2): optical signal, reflected from cornea is transmitted to photosensitive matrix (CCD-videomatrix), is converted into electric signal and then it is sent to the block of preliminary processing and across the interface the signal is transmitted for further analysis by IBM-compatible computer.

IV. MAIN FUNCTIONS OF OPTOELECTRONIC DEVICE

1. Obtaining of image. The device permits to obtain immediately images while studying microcirculation of eyeground, dynamic monitoring of images being possible.
2. Image processing. Program contains a set of methods of digital processing of images or their fragments, depending on user’s demand.
3. Possibility of archiving of patient’s data. The system provides creation, rapid search of computerized version of patient’s history of disease and editing of patient’s data.

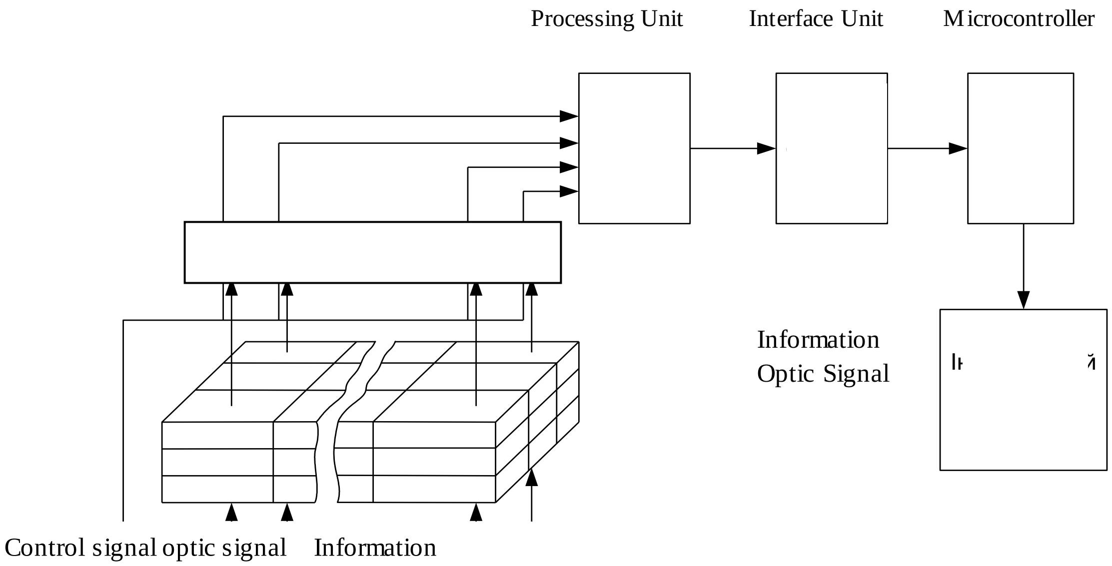

Fig. 2. Structural diagram of optoelectronic device:
Ph.M. – photomatrix

V. FINDINGS AND RESULTS

Algorithm of processing of secondary fluorescence image by intensity of luminous flux on the example of analysis of inflammatory process due to disease of cornea has been developed*(Patent of Ukraine 44404 A)*. The analysis comprises the following stages: at the first stage the image is written down in 2-dimensional matrix A (Fig.3). Then histogram is constructed based on intensity of image A (Fig.4), the next stage is determination of pathologic area and its geometric dimensions (Fig.5)

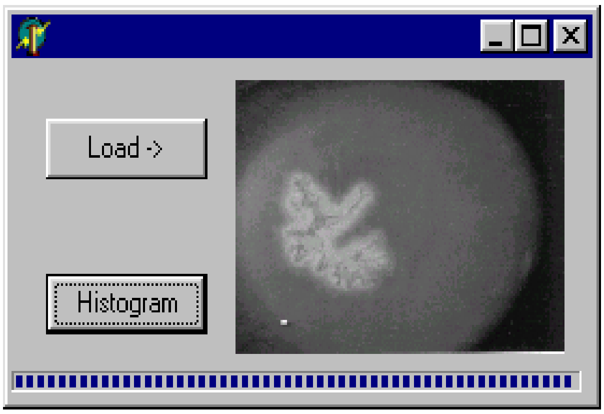

Fig. 3. 2-dimensional matrix A of the image of eye conjunctiva microcirculation

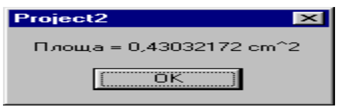

Fig. 5. Result of determination of pathology area by image A

The developed optoelectronic device allows to analyse hemodynamic indications of cardiovascular system (CVS, predict the course of pathological process and enables to determine the level of blood saturation. For evaluation of local microcirculation of vessels by indications of photoplethysmographic signals optoelectronic device intended for analysis of state of vascular system of eye conjunctiva was developed and implemented at National Vinnytsa Medical University (Ukraine) [5].

Results of research are given in Table 1.

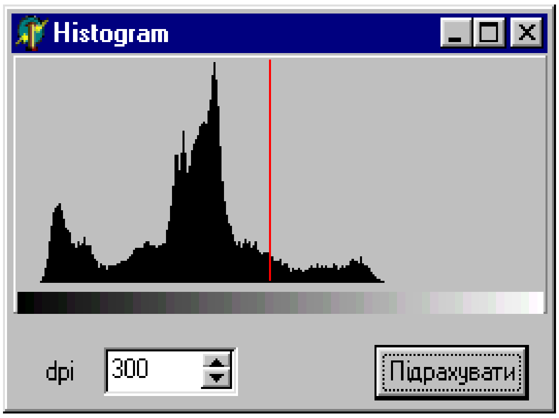

Fig. 4. Distribution of light intensity by image A gradings

TABLE I

Analysis Of Microcirculation Indications Based On Application Of Optoelectronic Devices Of "Eye-Processor" Type

Indication	Initial data		After blockade of vegetative impulses (15 min)	p(t) $p(\chi^2)$
	n	M ± m	M ± m	
Relation of diameters of arterioles and venues (points)	13	0	0	–
Disturbance of parallelism of vessels (points)	13	0	0,153±0,104	– >0,05
Irregularity of vessels gauge (points)	13	0	0,153±0,104	– >0,05
Twisting of vessels (points)	13	0	0,153±0,104	– >0,05
Venule sacculations (points)	13	0	0	–
Bloodstrokes (points)	13	0	0,153±0,104	– >0,05
Microthrombuses (points)	13	0	1,384±0,431	– <0,01
Total number of points	13	0	13,384±0,655	– <0,001

VI. CONCLUSIONS

In paper is proposed the following scientific and practical results were obtained in the course of research. These results were applied for the creation of the above-mentions optoelectronic devices in the form of intelligent screens:

1. Architecture of optoelectronic device of "eye-processor" type has been improved. The device is designed for transformation and storing of images applying automatic processing of images by means of introduction of blocks to carry out the comparison of reference image of the object g (x, y) and image of recognized object and background f (x, y). It is very important for image processing, especially in real time in dynamic systems.
2. Architecture of optoelectronic correlator is upgraded as a result of its realization on homogeneous matrix multilayer structure, that permits to apply uniform technological basis.
3. The study of different versions of circuits and designs as well as evaluation of efficiency of optoelectronic means of recording, processing and displaying of biomedical information has been carried out. The study proved high reliability of circuits and design needed for realization of individual optoelectronic operation display and other devices of similar designation.

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