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W-connectivity Spectrum Method for Analysis of Images by Laser Therapy

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Abstract: We present a novel specified method and its application for pattern analysis. The method is of multistage architecture, it investigates partial connectivity between structural image components. The proposed method and model is based on unified approach to biosignal treatment, that may be used in laser, heatgraph, ultrasonic, tomographic diagnosis.

Key words: Image, homodynamic, photo sensor, light flow intensity, temporal intervals duration, laser therapy, DCC-video matrix

INTRODUCTION

Analysis shows that characteristics of the suggested digital systems for object's detection and recognition including correlation-external coordinates meters does not comply meet the special requirements. Nowadays the volume of information, that is obtained, constantly increases and is accumulated, especially in information biomedical systems. These requirements include maximum simplicity for the maximum speed of response keeping high precision of calculations, high noise immunity, relative characteristics stability of the object of tracking, noise and adaptation to the apriority unknown hum[1,2]. There appears the need in creation of modern information devices and methods intended for processing of biomedical information by means of creation of basically new models and algorithms, which are based on increased completeness of image presentation and obtaining new features of biomedical objects.

MATERIALS AND METHODS

With the purpose of reduction of sensitivity to distortions and noise during image formation the article presents method image representation with the generalized space W-connectivity spectrum and proposes noise immunity algorithms of images comparison on its basis.

The conventional gray-scale image representation usually contains information about a two-dimensional light intensity function. Prior to performing any structural image analysis, such representation must be changed in order to highlight spatial regularities. One way of doing that is to provide a higher-level image description. However, complex components in such a description are very difficult to analyze using parallel techniques. Another approach of highlighting the spatial image regularities is to assign each pixel some structural value. Then this new image is segmented for parallel processing and each channel investigates some basic relationships between the structural components.

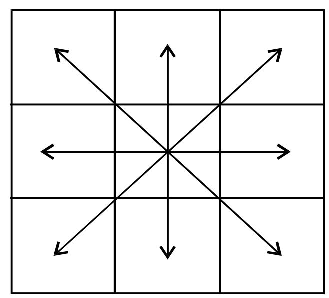

Fig. 1: Spatial 8-connectivity of a pixel (in the case of binary image)

The criterion of spatial connectivity is a very informative visual attribute and one of the most fundamental grouping principles. It explains a powerful tendency of the human visual system to perceive any uniform connected area as a single unit[1]. The spatial pixel connectivity (Fig. 1) has been chosen to represent local image structure. Then, the 8-connectivity value of each pixel varies from 0 to 8 in the case of binary images. In the case of gray-scale image it varies from 0 to 8+9+9=26 (3D dimensions).

The essence of image decomposition to a generalized W-connectivity spectrum consist in its division into areas

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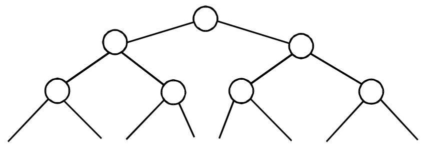

Fig. 2: Dichotomy principle used for image division

based on dichotomy principle (Fig. 2)[2], calculation of each pixel connectivity sums up all connectivity directions (partial W-connectivity sum) within the limits of each region and assigns to each partial W- connectivity sums to geometry centers of corresponding region. W-connectivity spectrum of the image (fragment) with the dimensions $m_x m_y m_z$ is defined as:

$$W_{\Sigma x,y,z} = \sum_{\gamma}^{26} \sum_{l}^{m_z} \sum_{i,j}^{m_x m_y} \alpha_{i,j,l}^{\gamma}$$

where, $a_{i,j,l}^{\gamma}$ - is the image element (fragment) with coordinates i, j, l and connectivity γ.

In case of multigradational image with $m_x m_y m_z$ dimensions and the same quantity of these pixels W-connectivity spectrum $W_{\Sigma 1x,y,z}$ of this image is defined as:

$$W_{\Sigma 1x,y,z} = 4\cdot 11\cdot(m_z - 2) + 4\cdot 2\cdot 7 + 2\cdot 17\cdot[(m_x + my) - 4]\cdot(m_z - 2) + 2\cdot 11\cdot[(m_x + +m_y) - 4] + 26\cdot(m_x - 2)\cdot(m_y - 2)\cdot(m_z - 2) + 2\cdot 17\cdot(m_x - 2)\cdot(m_y - 2)$$

where, $m_x, m_y, m_z \geq 2$.

W-connectivity spectrum of any gray-scale image is $0 \leq W_{\Sigma 1x,y,z} \leq W_{\Sigma x,y,z}$.

If $m_x = m_y = m_z = 1$, $W_{\Sigma 1x,y,z} = 0$.

Define space W-transforming image f(x, y, z) = $\{f_{i,j,l}\}$ by connectivity as:

$$f(x,y,z) = \{f_{i,j,l}\} \xrightarrow{W} W_{fn}(x,y,z) = \{w(r,v,p)_k\},$$

where: i = 0..(m_x-1), j = 0..(m_y-1), l = 0..(m_z-1), r = 1..m_y, v = 1..m_x, p = 1..m_z.

If p = 1 then k = 0..(rv-1), if p = 2 then k = 0..(2rv-1), ..., if p = n then k = 0..(nrv-1).

Multigradational images comparison algorithm consists of the following:

- Assign comparison error threshold visible by power 2).
- Define the maximal order (rvp-level) with p=1, k=0.. (rv-1); p=2, k=0.. (2rv - 1);...; p=n, k =0..(nrv - 1) of the compared images according to their W-coefficients of W-spectrum space connectivity, rvp$\leq m_x m_y m_z/2\delta$.
- Sort out by descending order of current image W-coefficients according to their rvp-levels and their values within the limits of current rvp-level.
- Subtract W-coefficients $w(r,v,p)_k$ of current image from W-coefficients of standard image, which can be defined in the same way and form the differences $\Delta f_g(r,v,p)_k$. Within the limits of each order by the fixed values r,v,p define the summary differences $F_g(r,v,p) = \sum^{k} \Delta f_g(r,v,p)_k$ and compare them with the threshold δ. The compared standard and current images are equal if all total differences are smaller than δ. If at least one total difference F_g(r, v, p) is not smaller than δ, they are not.

According to proposed method the program model has been created and tested using images of eye-pupil fragment turned under various angles.

RESULTS AND DISCUSSION

Basal Cell Carcinoma (BCC) is the most common malignant tumors in the white population. In the US more than one third of all cancers are non-melanoma skin cancers[3,4]. The treatment modalities include excision surgery, Moths' surgery, cry therapy with or without curettage, curettage alone, electrodessication, topical chemotherapy and radiotherapy. Another treatment modality is photodynamic therapy, which is of special interest with the introduction of topical application of o-amino laevulin acid (ALA). ALA is prepared in a 20% concentration in an oil-in-water base and is topically applied on the lesions 4-6 h before the laser therapy. ALA in aqueous solution has the property of penetrating abnormal but not normal keratin and can selectively pass through the damaged keratin of the tumors and an accumulation of protoporphyrin DC (Pp DC) occurs. The formation of Pp DC can be followed in real time by means of Laser-induced Fluorescence (LIF). An example of a BBC treated with ALA-PDT is shown in the Fig. 3. About 400 lesions were treated. Superficial BBC with a thickness less than 3 mm were treated with only one session of ALA-PDT. Thicker tumors need at least two treatment sessions. Nodular BCC with a cystic component seem to be resistant to ALA-PDT. A randomized clinical Phase HI

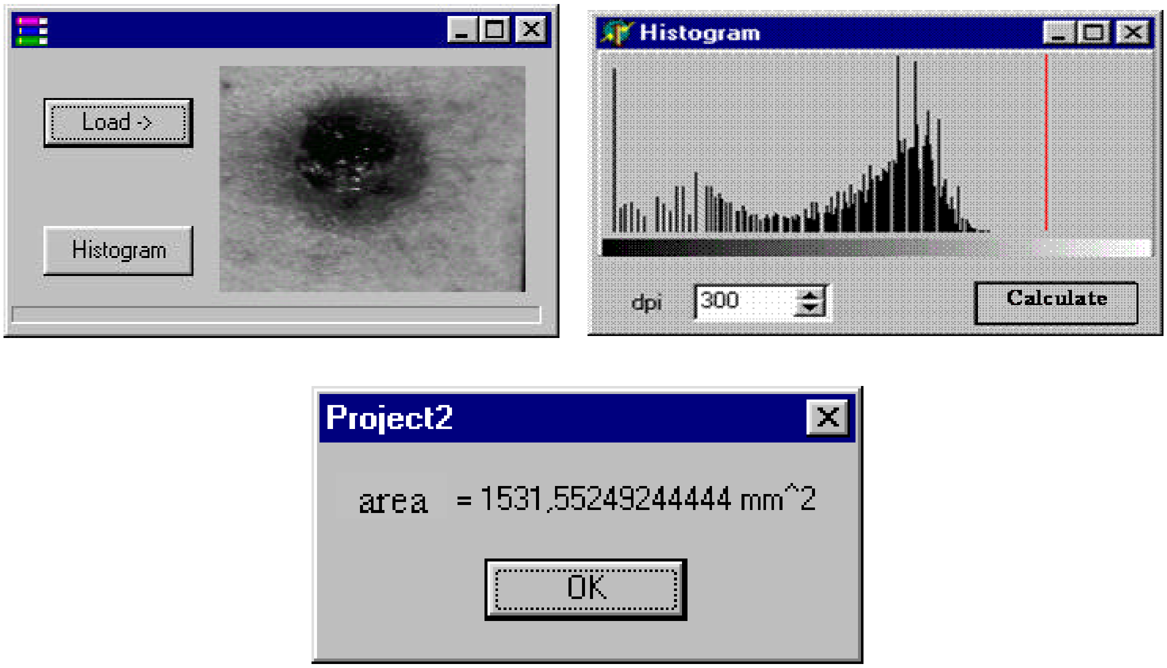

Fig. 3: A basal cell carcinoma (17 x 20 mm) before PDT using topical ALA sensitization and visible laser light irradiation and distribution of intensity

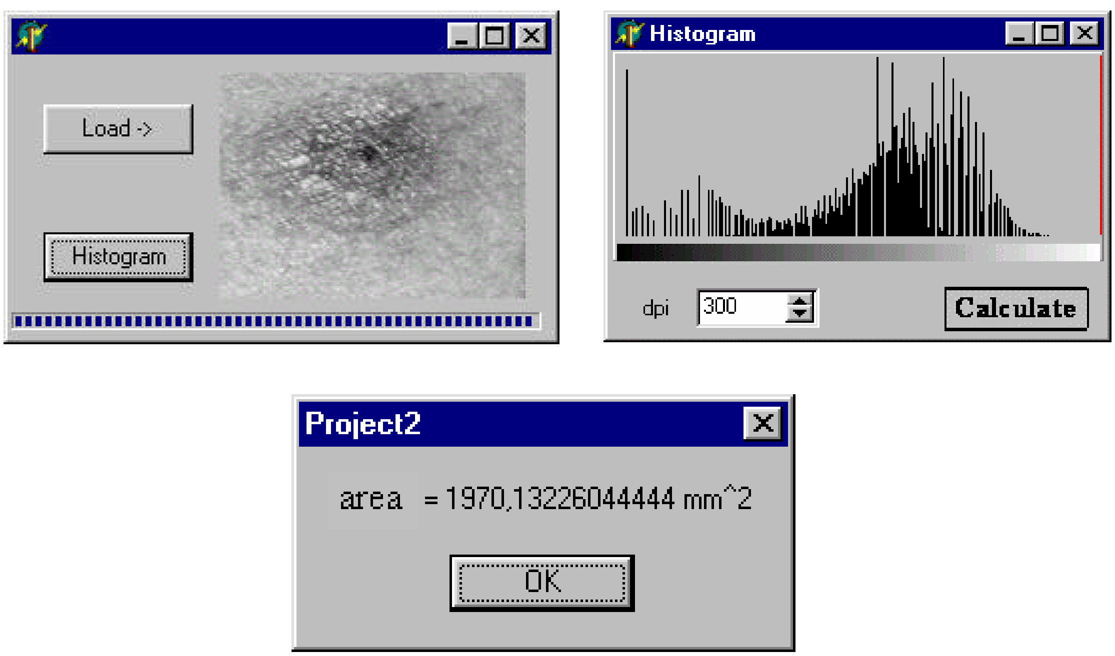

Fig. 4: A basal cell carcinoma (17 x 20 mm) after 3 weeks PDT using topical ALA sensitization and visible laser light irradiation and distribution of intensity

study is being conducted in which ALA-PDT is compared with cry therapy[4].

The laser therapy was applied as a single treatment at a total light dose of 60 J cm^{-2}, with a light power density below 110 mW cm^{-2}, for about 12 min. An example of a BBC treated with ALA-PDT after the laser therapy is shown in the Fig. 4.

This method allows more exactly making diagnostic of cornea disease, reducing time of processing and analysis of cornea image[5].

CONCLUSIONS

Analysis shows that characteristics of the present digital systems for object's detection and recognition including correlational-extremal coordinates meters does not comply with the special requirements. These requirements include maximum simplicity for the maximum speed of response keeping high precision of calculations, high noise immunity, relative characteristics stability of the tracking object and hum and adaptation to the priory unknown hum.

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