UDK 004.93

Natalya P. Volkova[1], Senior Lecturer, Department of Applied Mathematics and Information Technologies Computer Science Institute, E-mail: volkovanp30@gmail.com, Scopus ID: 36104775700,
ORCID: http://orcid.org/0000-0003-3175-2179
[1]Odessa National Polytechnic University, Shevchenko ave., 1, Odessa, Ukraine, 65044

DETECTOR QUASI-PERIODIC TEXTURE SEGMENTATION METHOD FOR DERMATOLOGICAL IMAGES PROCESSING

***Annotation**. Currently, digital diagnosis systems that process medical images are widely used in the diagnosis process in the field of healthcare. The purpose of such systems is to assist the doctor in establishing the diagnosis, or in monitoring changes in the patient's condition during treatment. Dermatology is one of the areas of medicine where the number of visits to a doctor is high. At the same time, the tasks of establishing a diagnosis and monitoring changes in the patient's condition during treatment are time-consuming and subjective and they depend on knowledge and experience of a dermatologist. However, today, digital systems for the diagnosis of dermatological diseases are not in every locality, expensive and are stationary systems. With the development of mobile information technologies, it became possible to develop mobile image processing systems for the analysis of dermatological diseases, which allow you to: receiving, analyze, and compare images before and after treatment at anytime, anywhere. One of the basic procedures in image processing systems is segmentation, the purpose of which is to reduce the amount of processed data. Segmentation methods can be classified as boundary-based methods and region-based methods. Dermatological disease images consist of regions which have difference by texture, that is, the segmentation problem is considered as the task of selection homogeneous regions by texture. The result of image processing depends on the quality of segmentation. To improve the quality of segmentation, in this work, we developed a detector quasi-periodic texture segmentation method for dermatological images processing, which contain quasi-periodic textures on a complex background in noisy conditions. This method is developed on the basis of the methodology of texture segmentation using detector, the stages of which are localization of spatial frequencies, detection, and contour segmentation. To localize of spatial frequencies, a wavelet-function improved by transform of graph of power function was used, which increases the accuracy of determining the boundaries of quasi-periodic textures contained in dermatological disease images. On the detection step, the comb filters, which are wavelets with a periodic or quasi-periodic transfer function that are applied to each image line, were used. The Canny method was use, as a contour preparation. Detector segmentation methods are focused on the image model. Therefore, a mathematical model of medical dermatological disease images was proposed, which contain quasi-periodic textures on a complex background in noisy conditions, as a model of a texture image with amplitude-modulated fluctuations in the intensity values by a random change in the amplitude and frequency of the oscillation. The developed method was applied to test medical images of psoriasis disease, which are available on the Internet. The accuracy of the segmentation of medical images of psoriasis disease containing a quasi-periodic texture was evaluated using the proposed method and the method using Gabor filters. It is shown that the proposed method is characterized by high speed and high segmentation quality, that is, it can be used in the development of express-diagnostic systems for monitoring changes in the patient's condition during treatment and to determine a parameter such as lesions area.*

***Keywords:** texture image segmentation; spectral texture; a Gabor transform; detector; dermatological disease images; wavelet functions; the generalized comb-scale function; confusion matrices*

Introduction

On the statistical data of Ministry of health of Ukraine 6 % seeking medical help are caused by dermatopathology. The dermatological diseases such as psoriasis, eczema, atopic dermatitis and drug disease are the most common. For the timely skin lesions diagnostics and tracking of the course diseases dynamics during the treatment and establish the efficiency of treatment methods, it is important to monitor the patient's skin lesions by the macro photography and dermoscopy constantly. With the development of telemedicine, it becomes important to use express-diagnostic systems [1], which help to carry out constant monitoring of the patient’s skin lesions and determine such basic parameters as Body Surface Area (BSA) and Psoriasis Area Severity Index (PASI), etc.

The analysis of existing digital systems of diagnostics of skin lesions (SDSL) is carried out, which are used in modern diagnostics of skin lesions. Modern SDSL, as a rule, consist of the following blocks: image pre-processing; image segmentation; image analysis. Examples of such systems are DBDermo-Mips (Italy), FotoFinder Dermoscope (Germany), SolarScan (Australia) [2]. However, these systems are cost-prohibitive and are stationary systems, which do not meet express-diagnostic and continuous patient monitoring, therefore, it is advisable to carry out research in this direction.

Problem formulation

Requirements regarding for the express-diagnostic devices have been formulated, which provide a dermatologist with the ability to monitor the patient's health at any time: low cost; the ability to capture images at any time; efficiency, low resource capacity.

Then the task of creating the digital system of express-diagnostics is reduced to the mobile application development that consists the following image processing and analysis blocks: receiving or downloading images; image pre-processing; image segmentation; determining the parameters of skin lesions and storing them in a database for subsequent analysis and transfer to a doctor. It should be noted that the decisive procedure that affects the quality of the express diagnostic system is the segmentation of skin lesions boundaries. For a reasonable choice of the image segmentation techniques, it is necessary to take into account the type of the analyzed image.

The analysis of the medical images of a number of dermatological diseases (for example, acne, psoriasis, atopic dermatitis) showed that such images can be considered as quasi-periodic textures on the complex background in noisy conditions. For example, psoriatic plaques are patches that are excessively dry, red, and raised above the skin surface. These patches are often covered with silvery-white flakes, called scales and combination of small, pale, gray or silver spots (“paraffin lakes”). Scales and “paraffin lakes” on the patches can be considered as texture elements that differ by shape, orientations and the distance between them is not different significantly (Fig. 1).

Fig.1. Psoriatic plaque image

The surface texture can be considered as smooth, rough, regular [3]. As a rule, two types of textures are considered – statistical and structural. Statistical texture [4] model are characterized by the presence or absence of spatial interaction between basic elements texture. There are a large number of image-texture segmentation methods today [5]. In general, methods can be classified as boundary-based methods (by the similarity property) and region-based methods (by the difference property) use parallel or sequential image processing algorithms [6]. Histogram-based methods [7] or correlation methods and other statistical methods are used to analyze statistical textures. For analyze the structural texture the structural and spectral methods (in the Fourier domain or wavelet transform) are used, because the structural texture consists of regularly or almost regularly distributed in space basic texture elements [8]. It should be noted that in the case of equidistant basic texture elements that have the same shape and orientation, the existing methods are quite effective. However, if basic elements texture form irregular (quasi-periodic) texture [3], i.e. they have random changes the coordinates of their determination in space, orientation and shape distortion, then the segmentation quality by structural or spectral methods does not meet the requirements of practice, in particular in the case of skin lesions image segmentation (Fig. 1), when the decisive characteristic is the accuracy of determining the boundaries of skin lesions.

As a rule, methods using Gabor filters [9–11], classification methods [12-14], and detector methods [15] are used to analyse quasi-periodic textures. The advantage of methods using Gabor filters is the ability to track basic texture elements. The method's deficiencies are high computational complexity and low-quality detection of homogeneous texture images bounds, especially in the quasi-periodic textures case [16]. The advantage of classification methods is the high-quality detection of homogeneous texture images bounds. But of the methods deficiencies is high computational calculation complexity. Detector methods have low computational calculation complexity, but not enough high quality detection of homogeneous texture regions bounds and need to present texture as mathematical model.

The aim of this work is to elaborate detector method for segmenting the images of quasi-periodic texture, which would improve quality detection of homogeneous texture regions bounds and speed of segmentation.

To accomplish the aim, the following tasks have been set:

– to elaborate quasi-periodic texture model;

– to elaborate stages in the detector quasi-periodic texture segmentation method for dermatological images processing;

– to experimentally research the detector quasi-periodic texture segmentation method using the images of the dermatological disease psoriasis.

Main part. To analyze the texture of the images dermatological disease, it was proposed to develop a model of quasi-periodic texture. Let $x=1,\ldots,N$, $y=1, \ldots ,M$ are spatial coordinates, $\Omega = \bigcup_{i=1}^{k} \Omega_i$ – partition the definition area of the image on k nonoverlapping regions Ω_i, $i=\overline{1,k}$, where texture features vector are slowly changing. Each line of the image of a dermatological disease (Fig. 2a) can be represented by the quasi-periodic sequence. The mathematical model of the quasi-

ISSN 2663-0176 (Print)
ISSN 2663-7731 (Online)

periodic sequence for the line *m* of the images can be present as follows:

$$I(x, y_m) = \bigcup_{i=1}^{k} \{c_i(x, y_m) + \sum_{j=1}^{n} \xi_j A_{ij}(x, y_m) \cos(\eta_j \omega_{ij} x) + $$
$$+ N_i(x, y_m), (x, y_m) \in \Omega_i\} \quad , \qquad (1)$$

where:

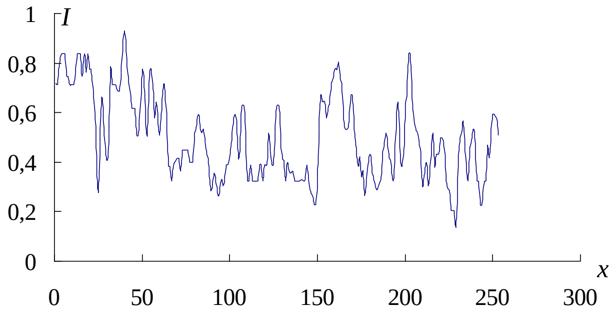
$c_i(x, y_m)$ – is a background on the segment *i* of the line *m* of the image;

$A_{ij}(x, y_m)$, ω_{ij} – accordingly the amplitude and frequency of the amplitude modulated component *j* on the segment *i* of the line *m* of the image;

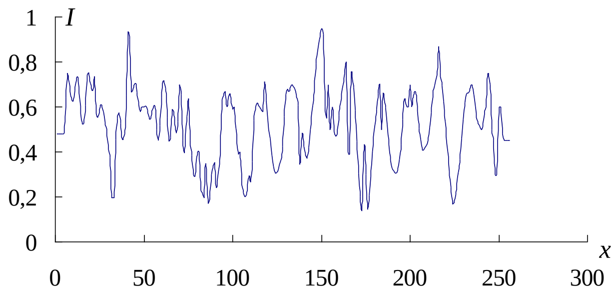
ξ_j, η_j – accordingly random amplitude and frequency changes of the amplitude modulated component *j;*

$N_i(x, y_m)$ – is white Gaussian noise with the zero mean and the σ_i^2 variance.

The given fragment of the graphical representation (Fig. 2b) of this model shows its similarity with the line of the real image of the dermatological disease psoriasis.



a



b

Fig. 2. Fragment the line of the image:
a – psoriatic plaque; b – for the model as a quasi-periodic signal

On the Fig. 2 the abscissa shows the value of spatial coordinate x, which corresponding pixel image index. The ordinate shows the value of intensity line *m* of the texture image.

The developed model takes into account two signal characteristic features, which shows line of the dermatological disease image – frequency-spatial localization (change frequency components in space) and the additive of the frequency components (the presence of several frequency components). When analyzing such signals, these features require to use of wavelet transforms for underline boundaries basic texture elements (take into account the frequency-spatial localization), and comb filters to select basic texture elements of the quasi-periodic textures (take into account the additive of the frequency components). In view of these considerations is proposed a detector method for quasi-periodic textures images segmentation.

Detector quasi-periodic texture segmentation method for dermatological images processing

Texture segmentation of images is determined by the local density of intensity fluctuations , therefore, to take into account the texture and tone features, it is appropriate to apply to the image that is recognized a transformation which has the property of frequency-spatial localization. Gabor wavelets relate to such transformations. They are Gaussian modulated complex sinusoids [16]. Gabor wavelets are implemented as band-pass filters and can be tuned to the frequency content of the image. But, as noted above, when applying Gabor wavelets to detection the bounds of the quasi-periodic texture, they give a high error.

The detector methods based on wavelet transform have the frequency-spatial localization property. The steps of the methodology of texture images segmentation using detector are: localization of spatial frequencies; detector; contour segmentation. At the localization stage a spatial frequency region is highlighted, in which the amplitude-frequency modulating image component is localized, that corresponds to the statistical spatial relationship of the basic texture elements (texture feature) [17].

Detector allows determining the moment of the signal amplitude and frequency changes with high noise stability as a result of using use low-pass filter and characterized of high speed. Thus, proposed the detector quasi-periodic texture segmentation method for dermatological images processing on the base of the methodology of texture images segmentation using detector. The steps of the proposed method are:

1. Underline boundaries basic quasi-periodic texture elements, which are presents on the medical images. For this, we convoluted the initial image with wavelet filter g_s^{new}(4) both in rows and in columns

$$I_s(x, y_m) = I(x, y_m) * g_s^{new}, \qquad (2)$$

where:

$I(x,y_m)$ – the line m of the quasi-periodic texture images;

"*" – convolution operator.

The wavelet filter g_s^{new} coefficients were obtained in [18] as result of uniform discretization wavelet-function at x>0 i x<0, improved by transform of graph of power function:

$$\psi_s(x)=\begin{cases}\dfrac{1}{s(x+\frac{1}{s}-1)}, & x>0,\\ \dfrac{1}{s(x-\frac{1}{s}+1)}, & x<0,\\ 0, & x=0,\end{cases} \quad (3)$$

where: s – parameter of scale (s <1).

The coefficients of the wavelet filter g_s^{new} coefficients are:

$$g_s^{new}=\left\{-\frac{1}{s\cdot k+1},\dots,-\frac{1}{s\cdot 2+1},-\frac{1}{s+1},\right. \\ \left.-1,1,\frac{1}{s+1},\frac{1}{s\cdot 2+1},\dots,\frac{1}{s\cdot k+1}\right\}, \quad (4)$$

where: k – parameter, which determines the number of filter coefficients.

The value of this parameter affects the noise stability of method that is, with an increase in the number of filter coefficients, the noise stability of the method is provided.

2. For further processing, is calculated the module of the obtained in the previous step result of underline boundaries basic quasi-periodic texture elements, which are presents on the medical images

$$I_M(x,y_m)=\left|I_s(x,y_m)\right|.$$

3. To select basic quasi-periodic texture elements, which are presents on the medical images proposed to use comb filters - wavelets with periodic or quasi-periodic transfer function (TF).

A comb filter is used as a filter, which matched with a periodic signal; in this case the frequencies of the maximums in the signal spectrum coincide with the frequencies of the maximums of the amplitude-frequency characteristics of the comb filter [19]. The comb filter bandwidth is represents the combination of the bandwidths of a set of the band-pass filters. As a result of such filtering, the estimate feature segmentation and transformation it to intensity by the image processing on a single scale.

The analyzing functions are intended for multi-scale image details processing. They are constructed by solving the two-scale difference equation [16] on the grid

$$\phi(x)=\sum_{n=0}^{N}c_n\phi(kx-n), \quad (5)$$

where:

$n, k \in Z$, $k \geq 2$, $x \in R$, $c_n \in C$, n, k, c_n – constants;

N – the number of components in equation (5);

$\phi(x)$ – unknown function.

To find an approximate solution to equation (5) the method of successive approximations is applied. According to this method, the solution of equation (5) is a fixed point $\phi(x)=G\phi(kx-n)$ of a linear operator $G\phi(x)=\sum_{0}^{N}c_n\phi(kx-n)$.

To find this point, an iterative scheme $\varphi_j(x)=G\varphi_{j-1}(x)$, $j=\overline{1,k}$ is applied to the initial approximation $\varphi_0(x)$:

$$\varphi_0(x)=\begin{cases}1-|x|, x\in[-1/2,1/2]\\ 0, \text{otherwise}\end{cases}. \quad (6)$$

The generalized comb-scale function – is a solution of equation (5) for which $\Delta=\frac{1}{k}\sum_{n=0}^{N}c_n=1$.

The coefficients $\{c_n\}_{n=0}^{N}$ two-scale difference equation (5) calculated by the formula $\{c_n\}_{n=0}^{7}=$

$$\left\{-\frac{1}{2^{3+\alpha}},\frac{1}{2^{2+\alpha}},-\frac{1}{2^{1+\alpha}},1,1,-\frac{1}{2^{1+\alpha}},\frac{1}{2^{2+\alpha}},-\frac{1}{2^{3+\alpha}}\right\},$$

where: parameter α was chosen of the set $\{1,2,3\}$.

4. If necessary, binarization and morphological processing of the results are carried out and the parameters of the dermatological disease necessary for the diagnostic solution are calculated.

An experimental research of the detector quasi-periodic texture segmentation method using dermatological disease images

An experimental research of the proposed detector quasi-periodic texture segmentation method using dermatological disease images was carried out in the Matlab computer simulation system. By conducting an experiment, we compared the quality of segmenting the dermatological disease images that contain a quasi-periodic texture for the proposed method and method using Gabor filters.

We estimated segmentation quality for 50 test images of psoriasis disease of size *m*x*n* pixels (taken on the site https://www.dermnetnz.org/). An expert

ISSN 2663-0176 (Print)
ISSN 2663-7731 (Online)

dermatologist marked the required regions on the test images, which made it possible to use them for estimating the proposed algorithms.

The segmentation procedure involves pre-processing, detection of basic texture elements (using the proposed method or a method based on Gabor filters), binarization, morphological processing and psoriatic plaque area calculation.

Since, as a result of uneven illumination, the image has a multiplicative noise on it, so homomorphic filtering was used for image pre-processing [4].

Binarization of images, both obtained as a result of using the detector method and the method using Gabor filters, was carried out the Otsu's method [3].

The morphological processing of the binary image were applied morphological operation closing and opening to smooth out the objects contours, join narrow breaks and fill the small holes. Morphological operation erosion was applied to delete unimportant on sizes details [3].

The quality of segmentation when using the proposed method and the method using Gabor filters in comparison with the expert dermatologist marked test images was assessed by constructing confusion matrices [20].

In the confusion matrices the percentage of the image pixels which belonging to the skin lesions and segmented as pixels of the skin lesions indicate as TP (true positive). FN (false negative) – the percentage of the image pixels which belonging to the healthy skin and segmented as pixels of the skin lesions. TN (true negative) – the percentage of the image pixels which belonging to the healthy skin and segmented as pixels of the healthy skin. FP (false positive) – the percentage of the image pixels which belonging to the skin lesions and segmented as pixels of the healthy skin. Then the segmentation accuracy is determined by the formula [21]:

$$\frac{(TN+TP)}{(TN+TP+FP+FN)}\,. \quad (7)$$

A confusion matrices – is a square matrix NxN, where: N – number of classis. Matrix rows correspond the image pixels, which marked by dermatologist. Columns in a confusion matrix correspond the image pixels, which obtained with the help of the examined method. The element of the confusion matrix p_{ij}, i, j=1…N – is percentage of the i class pixels, which were correspond to the j class [17]. The Tables 1 and 2 are the confusion matrices for the proposed method and the method using Gabor filters, accordingly. The tables show the average values for the original image.

An example of the original images of psoriasis disease with the expert dermatologist marks and images obtained as a result of applying the proposed detector method and the method using Gabor filters are shown on the Figures 3 and 4.

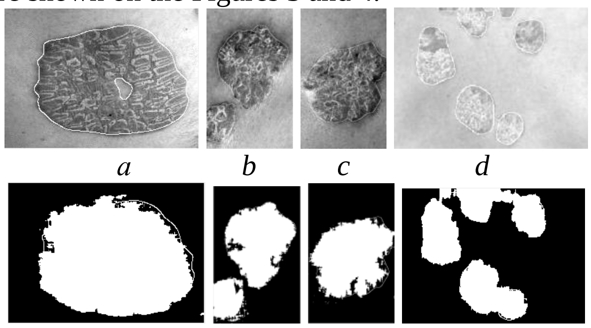
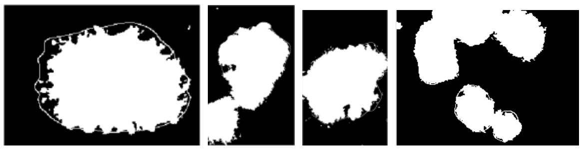


Fig. 3. Result of segmentation the images of psoriasis disease using the proposed detector method:
original images of psoriasis disease with the expert dermatologist marks (a–d);
result of segmentation the images of psoriasis disease with the expert dermatologist marks (white color – psoriatic plaque, black color – healthy skin) (e-h)



a *b* *c* *d*

Fig. 4. Result of segmentation the images of psoriasis disease using the method using Gabor filters:
result of segmentation the images of psoriasis disease with the expert dermatologist marks (white color – psoriatic plaque, black color – healthy skin) (a-d)

Table 1

Confusion matrices for the proposed method

Result of expert image marks, %	Result of image segmentation by the proposed method %	
	Psoriatic plaque	Healthy skin
Psoriatic plaque	87,47775	12,52225
Healthy skin	13,07947	86,92053

Table 2
Confusion matrices for the method using Gabor filters

Result of expert image marks, %	Result of image segmentation by the method using Gabor filters, %	
	Psoriatic plaque	Healthy skin
Psoriatic plaque	80,84533	19,15468
Healthy skin	13,68718	86,31282

Thus, the quality of segmentation the dermatological disease images that contain a quasi-periodic texture for the proposed method is 87%, and for the method using Gabor filters – 82%. So, the proposed method gives results that are better than the results of the method using Gabor filters by 5%. During the experiment, three types of images were considered: images containing large plaques; Images containing large and small plaques; and images that contain only small plaques. The quality of segmentation of images with large plaques by the proposed method was, on average, 93 %, for images of the two second types – 87 %. For the method using Gabor filters, the quality of segmentation of images with large plaques was, on average, 89 %, for images of two second types – 80 %

Thus, the proposed detector method can be recommended for determining the region of quasi-periodic texture in images of psoriasis diseases in order to increase the accuracy of detection texture regions of the image.

Conclusions

1. The model of quasi-periodic texture for the line of the dermatological disease images was developed. This model takes into account frequency-spatial localization and additive of the frequency components of signal.

2. The detector quasi-periodic texture segmentation method for dermatological images processing was developed. In this method, to underline the boundaries of basic texture elements of quasi-periodic textures, wavelet functions are used, which improved by transforming a power function. To select basic texture elements of the quasi-periodic textures, which are presents on the medical images for further processing the comb filters was used. The proposed detector method for quasi-periodic textures images segmentation has made it possible to improve quality of detecting the texture regions boundaries.

3. The obtained results of experimental researches showed that the developed method compared to the method using Gabor filters gave higher segmentation accuracy.

Thus, all the tasks are completed, the research aim is achieved.

Further researches will focus on improving the quality of detecting the texture regions boundaries using a combination of classification and detector methods with sufficient to practice processing time.

References

1. Makara, I. V., Melnik, S. A., Koguhar, O. T. & Saliy, L. S. (2015). “Zastosuvannja mul'tyspektral'nyh vymirjuvan' v dyferencial'nij diagnostyci pigmentnyh ta bezpigmentnyh urazhen' shkiry”. [The use of Multispectral Measurements in the Differential Diagnosis of Pigmented and Pigment less Skin Lesions]. *Perspektyvni tehnologii' ta prylady, Zbirnyk naukovyh prac'*, Vypusk 7, (gruden', 2015), pp. 81-86 (in Ukrainian).

2. Marghoob Ashfag A., Mavehy, J. & Braun Ralph, P. (2012). “Atlas of Dermatoscopy”. *Taylor & FrancisGroup*, 387p.

3. Gonsales, R. & Vuds, R. (2005). “Cifrovaja obrabotka izobrazhenij”. [Digital Image Processing], Moscow: Russian Federation, *Publ. Tehnosfera*, 1072 p. (in Russian).

4. Antoshhuk, S. G. & Serbina, N. A. (2002). “Sistema raspoznavanija teksturnyh izobrazhenij pri jekologicheskom monitoringe” [Texture Image Recognition System for Environmental Monitoring], *Iskusstvennyj intellect*, Vol. 4, pp. 406-413.

5. Shybajeva, S. V. & Babilunga, O. Ju. (2018). “Arhitektura zgortkovoi' nejronnoi' merezhi dlja segmentacii' teksturnyh zobrazhen” [Architecture of a Concurrent Neural Network for Segmentation of Textural Images], *Modern Information Technology – Suchasni Informacijni Tehnologii'* 2018. Odesa: *Ekologija*, pp. 175-176.

6. Hanykov, I. G. (2018) “Klassifikacija algoritmov segmentacii izobrazhenij” [Classification of Image Segmentation Algorithms]. *Izv. Vuzov. Priborostroenie.* Vol. 61 No. 11, pp. 978-987. Doi: 10.17586/0021-3454-2018-61-11-978-987 (in Russian).

7. Ishchenko, A. V., Polyakova, M. V. & Nesteryuk, A. G. (2019). “The Technique of Extraction Text Areas on Scanned Document Image Using Linear Filtration”. *Applied Aspects of Information Technology*, Vol. 2, No. 3, pp. 206-215.

8. Chen, K. (2013). “Introduction to Variational Image-Processing Models and Applications”, *International Journal of Computer Mathematics,* Vol. 90, No. 1, pp. 1-8.
Doi:10.1080/ 00207160. 2012.757073.

ISSN 2663-0176 (Print)
ISSN 2663-7731 (Online)

9. Nailon, W. H. (2010). “Texture Analysis Methods for Medical Image Characterization”. London: *INTECH Open Access Publisher*, pp. 978-987. Doi:10.5772/8912.

10. Kodeeswari, C., Sunitha, S., Pavithra, M. & Santhia, K. R. (2014). “Automatic Segmentation of Scaling in 2-D Psoriasis Skin Images Using SVM and MRF*”, International Journal of Advances in Science Engineering and* Technology, Vol. 2, Issue-2, pp. 31-35.

11. Bolkote Ashwini, C. & Tadwalkar, M. B. (2014). “An Analysis of Psoriasis Skin Images”, *International Journal of Inventive Engineering and Sciences (IJIES)*, Vol. 2, Issue-12, pp. 17-22.

12. Jarad Tanya Shakir, Dawood Ali J. & Meteab Zainab Hafedh. (2017). “Computer-Aided Diagnosis Psoriasis Lesion and Other Skin Lesions Using Skin Texture Features and Combination”, *Journal of Software Engineering & Intelligent Systems*, Vol. 3, Issue-13, pp. 243-253.

13. Juang Li-Hong & Wu Ming-Ni. (2011). “Psoriasis Image Identification Using k-means Clustering with Morphological Processing”, *Measurement*, Vol. 44, No. 5, pp. 895-905.

14. Jarad Tanya Shakir & Dawood Ali J. (2017). “Accurate Segmentation of Psoriasis Diseases Images Using k-means Algorithm Based on CIELab Color Space”, *Journal of Theoretical and Applied Information Technology*, Vol. 95, No. 17, pp. 4201-4210.

15. Abakumov, V. G., Antoshhuk S. G. & Krylov V. N. (2008). “Bazovye metody obrabotki biomedicinskih izobrazhenij”. [Basic Methods for Processing Biomedical Images], *Jelektronika i svjaz'*, Ch. 2., pp. 53-58 (in Russian).

16. Poljakova, M. V. & Krylov, V. N. (2007). “Obobshhennye masshtabnye funkcii s kompaktnym nositelem v zadache segmentacii izobrazhenij uporjadochennyh tekstur”. [Generalized Scale Functions with a Compact Medium in the Problem of Image Segmentation of Ordered Textures], *Avtomatika. Avtomatizacija. Jelektrotehnicheskie kompleksy i sistemy: mezhvuzovskij zhurnal.* – Herson: *HNTU*, No. 1, pp. 75-84 (in Russian).

17. Krylov, V. N., Poljakova, M. V. & Volkova, N. P. (2006). “Metod teksturnoj segmentacii izobrazhenij s primeneniem detektirovanija”. [The Method of Texture Segmentation of Images using Detection], *Vestnik HNTU*, Vypusk 2, No. 25, pp. 226-270 (in Russian).

18. Poljakova, M. V., Krylov, V. N. & Volkova, N. P. (2012). “Metod postroenija uluchshennyh vejvletov putem preobrazovanija grafika stepennoj funkcii dlja zadachi konturnoj segmentacii izobrazhenij”. [The Method of Wavelets Construction by Transformation of a Graph of Power Function for edge Detection], *Mezhdunarodnyj nauchnyj zhurnal “Komp'juting”*, Vol. 11, Vypusk 3, pp. 203-214 (in Russian).

19. Chesnokov, M. A. (2013). “Cifrovoj grebenchatyj fil'tr s liniej zaderzhki prodolzhitel'nost'ju v drobnoe chislo otschetov”. [Digital Comb Filter with Fractional Sample Delay Line], *Nauchno-tehnicheskie vedomosti SPbGPU. Informatika. Telekommunikacii. Upravlenie*, 5(181), pp. 9-15 (in Russian).

20. Polyakova, M., Ishchenko, A., Volkova, N. & Pavlov, O. (2018). “Combined Method for Scanned Documents Images Segmentation Using Sequential Extraction of Regions”, *Eastern-European journal of enterprise technologies*, Vol. 5, No. 2, pp. 21-28,
DOI: 10.15587/1729-4061.2018.142735.

21. Zaharov, A. V., Kol'cov, P. P., Kotovich, N. V., Kravchenko, A. A., Kucaev, A. S. & Osipov, A. S. (2012). “Kriterii ocenki kachestva segmentacii izobrazhenij”. [Criteria for Assessing the Quality of Image Segmentation], *TRUDY NIISI RAN*, Vol. 2, No. 2, pp. 87-99 (in Russian).

Received 22.10.2019
Received after revision 15.11.2019
Accepted 29.11.2019

УДК 004.93

[1]**Волкова, Наталія Павлівна,** старший викладач кафедри прикладної математики та інформаційних технологій інституту комп’ютерних систем, E-mail: volkovanp30@gmail.com, Scopus ID: 36104775700, ORCID: http://orcid.org/0000-0003-3175-2179
[1]Одеський національний політехнічний університет, пр. Шевченка, 1, м. Одеса, Україна, 65044

ДЕТЕКТОРНИЙ МЕТОД СЕГМЕНТАЦІЇ КВАЗІПЕРІОДИЧНИХ ТЕКСТУР ДЛЯ ОБРОБКИ ЗОБРАЖЕНЬ ДЕРМАТОЛОГІЧНИХ ЗАХВОРЮВАНЬ

Анотація. *На даний час при постановці діагнозу в сфері охорони здоров'я широко застосовуються цифрові системи медичної діагностики, які обробляють медичні зображення. Призначенням таких систем є допомога лікарю під час встановлення діагнозу, або при моніторингу змін стану пацієнта під час лікування. Дерматологія є однією з областей медицини, де кількість звернень до лікаря є високою. При цьому задачі встановлення діагнозу і моніторингу змін стану пацієнта під час лікування є трудомісткими та суб'єктивним і залежить від знань і досвіду лікаря-дерматолога. Однак, на сьогоднішній день, цифрові системи діагностики дерматологічних захворювань, є не в кожному населеному пункті, вони мають надмірну вартість і є стаціонарними системами. З розвитком інформаційних мобільних технологій з'явилася можливість розробки мобільних систем обробки зображень дерматологічних захворювань, які дозволяють: отримати, проаналізувати, виконати порівняння зображень до і після лікування в будь який час, в будь якому місті. Однією з базових процедур в системах обробки зображень є сегментація, метою якої є зниження об'єму оброблюваних даних. Методи сегментації можна поділити на методи на основі виділення границь і методи на основі виділення областей. Зображення дерматологічних захворювань складаються з областей, які відрізняються за текстурою, тобто розглядається задача сегментації, як задача виділення областей, які є однорідними за текстурою. Результат обробки зображень залежить від якості сегментації. Для підвищення якості сегментації у даній роботі розроблено детекторний метод сегментації квазіперіодичних текстур для обробки зображень дерматологічних захворювань, які містять квазіперіодичні текстури на складному фоні в умовах завад. Даний метод розроблено на основі методології текстурної сегментації з використанням детектування, етапами якої є – локалізація просторових частот, детектування, контурна сегментація. Для локалізації просторових частот застосовано вейвлет-функції, поліпшені шляхом перетворення ступеневої функції, що підвищує точність визначення границь квазіперіодичних текстур, що містяться на зображеннях дерматологічних захворювань. На етапі детектування застосовано гребінчасті фільтри, які є вейвлетами з періодичною або квазіперіодичною передаточною функцією, які застосовуються до кожного рядка зображення. В якості контурного препарату застосовувався метод Канни. Детекторні методи сегментації орієнтовані на модель зображення, тому було запропоновано математична модель медичних зображень дерматологічних захворювань, які містять квазіперіодичні текстури на складному фоні в умовах завад, як модель текстурного зображення з амплітудно-модульованими коливаннями значень інтенсивності з випадковою зміною амплітуди і частоти коливання. Розроблений метод було застосовано до тестових медичних зображень хвороби псоріаз, які є доступними в мережі Internet. Було проведено оцінку точності сегментації медичних зображень хвороби псоріаз, які містять квазіперіодичні текстури запропонованим методом і методом з використанням фільтрів Габора. Показано, що запропонований метод характеризується високою швидкодією і якістю сегментації, тобто може бути застосовано при розробці систем експрес-діагностики для моніторингу змін стану пацієнта під час лікування і визначення такого параметру, як площа шкіри ураженої хворобою.*

Ключові слова: *текстурна сегментація зображень; спектральна текстура; перетворення Габора; детектування; зображення дерматологічних захворювань; вейвлет-функції; узагальнена гребінчаста масштабна функція; матриця неточностей*

УДК 004.93

[1]**Волкова, Наталья Павловна,** старший преподаватель кафедры прикладной математики и информационных технологий, института компьютерных систем, E-mail: volkovanp30@gmail.com, Scopus ID: 36104775700, ORCID: http://orcid.org/0000-0003-3175-2179
[1]Одесский национальный политехнический университет, пр. Шевченко, 1, г. Одесса, Украина, 65044

ДЕТЕКТОРНЫЙ МЕТОД СЕГМЕНТАЦИИ КВАЗИПЕРИОДИЧЕСКИХ ТЕКСТУР ДЛЯ ОБРАБОТКИ ИЗОБРАЖЕНИЙ ДЕРМАТОЛОГИЧЕСКИХ ЗАБОЛЕВАНИЙ

Аннотация. *В настоящее время при постановке диагноза в сфере здравоохранения широко применяются цифровые системы медицинской диагностики, которые обрабатывают медицинские изображения. Назначением таких систем является помощь врачу при установлении диагноза, или при мониторинге изменений состояния пациента во время лечения. Дерматология является одной из областей медицины, в которой количество обращений к врачу высоко. При этом задачи установления диагноза и мониторинга изменений состояния пациента во время лечения являются трудоемкими и субъективными и зависят от знаний и опыта врача-дерматолога. Однако, на сегодняшний день, цифровые системы диагностики дерматологических заболеваний, есть не в каждом населенном пункте, они имеют избыточную стоимость и являются стационарными системами. С развитием информационных мобильных технологий появилась возможность разработки мобильных систем обработки изображений дерматологических заболеваний, которые позволяют: получить, проанализировать, выполнить сравнение изображений до и после лечения в любое время, в любом месте. Одной из базовых процедур в системах обработки изображений является сегментация, целью которой является снижение объема обрабатываемых данных. Методы сегментации можно разделить на методы на основе выделения границ и методы на* *основе выделения областей. Изображения дерматологических заболеваний состоят из областей, которые отличаются по текстуре, то есть рассматривается задача сегментации, как задача выделения областей, которые являются однородными по текстуре. Результат обработки изображений зависит от качества сегментации. Для повышения качества сегментации в данной работе разработан детекторній метод сегментации квазипериодических текстур для обработки изображений дерматологических заболеваний, которые содержат квазипериодические текстуры на сложном фоне в условиях помех. Данный метод разработан на основе методологии текстурной сегментации с использованием детектирования, этапами которой являются - локализация пространственных частот, детектированиие, контурная сегментация. Для локализации пространственных частот использованы вейвлет-функции, улучшенные путем преобразования степенной функции, что повышает точность определения границ квазипериодических текстур, содержащихся на изображениях дерматологических заболеваний. На этапе детектирования применены гребенчатые фильтры, которые являются вейвлетами с периодической или квазипериодических передаточной функцией. В качестве контурного препарата применялся метод Канни. Детекторные методы сегментации ориентированы на модель изображения, поэтому была предложена математическая модель медицинских изображений дерматологических заболеваний, которые содержат квазипериодические текстуры на сложном фоне в условиях помех, как модель текстурного изображения с амплитудно-модулированными колебаниями значений интенсивности со случайной сменой амплитуды и частоты колебания. Разработанный метод был применен к тестовым медицинским изображениям болезни псориаз, которые доступны в сети Internet. Была проведена оценка точности сегментации медицинских изображений болезни псориаз, содержащих квазипериодические текстуры предложенным методом и методом с использованием фильтров Габора. Получено, что предложенный метод характеризуется высоким быстродействием и качеством сегментации, и может быть рекомендован при разработке систем экспресс-диагностики для мониторинга изменений состояния пациента во время лечения и определения такого параметра, как площадь кожи пораженной болезнью.*

Ключевые слова: *текстурная сегментация изображений; спектральная текстура; преобразование Габора; детектирование; изображения дерматологических заболеваний; вейвлет-функции; обобщенная гребенчатая масштабная функция; матрица неточностей*

Natalya P. Volkova
Senior Lecturer of Department of Applied Mathematics and Information Technologies
Research field: digital image processing, pattern recognition