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WAVELET CORRECTION OF GRAPHIC IMAGES IN MULTIMEDIA TECHNOLOGIES

The article discusses one of the methods of improving the quality of graphic images using scale-selective wavelet analysis. New optical and polarization methods of graphic image processing using scale-selective wavelet filtering for selection of information and background components are analyzed

Keywords: graphic image; laser; wavelet analysis; light intensity; polarization; digital camera.

Introduction

A wide variety of graphic images, practical ignorance and complexity of their optical and polarizing structure objectively determines the need to search for more universal mapping techniques that allow statistically reliably studying the structure of objects while taking into account a set of mechanisms for light scattering by Paper media and optical anisotropy of polymer substrates.

One of the most important areas for improving the quality of graphic images can be the analytical application of basic Fourier optics algorithms in methods of optical reading (mapping) of topographic information.

Such analytical approaches make it possible to perform an instrumental operation of consistent spatial-frequency filtering of graphic images, which are coordinate (two-dimensional) distributions of parameters (intensity and polarization states) of the scattered radiation field.

As a result, there is an analytical or instrumental possibility of separation and separate study of multiscale distributions of information and background parameters of a graphic image.

To implement such tasks, there is a need for the following analytical steps.

1. Development of a model of material carriers (substrates) of graphic

information, that justifies the formation and transformation of polarization maps of azimuth and ellipticity of graphic images and their Fourier Spectra.

2. Determination of the relationships between the coordinate distributions of azimuth and ellipticity of the Fourier spectra of polarization-inhomogeneous graphic images and the parameters of linear and circular birefringence of polymer carriers.

3. Development of a new analytical and instrumental method for Fourier polarimetry of spatial and frequency spectra of graphic images.

Method

Recently, systems for digital registration, processing and transmission of graphic images of various directions — from diagrams, drawings, texts, documentation, advertising products — have been intensively developing.

Optical images of graphic information contained on various media (substrates) — from paper to polymer — contain several components.

The first is information, which contains a direct topographic component.

The second one is the background one, which is formed by a light-colored background [1–3]. This background worsens the contrast of graphic information and distorts its topographic structure. The geometric scales of such components are different.

The information component is large-scale topographic structures. The background component is large-scale topographic structures formed by optically inhomogeneous fields of two types [4, 5].

The first is the coordinate — inhomogeneous intensity distributions of optical radiation scattered by paper carriers in the graphic image plane.

The second is the distribution of states (azimuth and ellipticity) of scattered optical radiation by Polymer carriers that are coordinate — inhomogeneous in the plane of the graphical representation.

For the development of methods for improving the quality of graphic images, the task of instrumental and optical differentiation of such components is relevant.

Currently, known methods for recording optical information do not solve this problem.

One of the most effective approaches to improving the quality of graphic images can be the method of large-scale selective wavelet analysis of optical field parameters [6–11].

Thus, it is relevant to develop new optical and polarization methods for processing graphic images on dimensional media using algorithms of scale-selective wavelet analysis for selecting information and background components.

Development of new approaches to the analytical description of graphic images on polymer media on a polarization-inhomogeneous background substantiation of new digital processing methods using scale-selective wavelet analysis of polarization manifestations of birefringence mechanisms of optically anisotropic materials.

To achieve this goal, the following task is considered — the development and analytical substantiation of the principles of large-scale selective wavelet selection of information (macro-scale) and back-ground (micro-scale) components of a polymer-based graphic image.

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Results

Brief theory

In order to obtain reliable (azimuthally invariant) information is illuminated by a right-circularly (⊗) polarized beam with azimuth α_0, the Stokes vector of which has the following form [1–3]:

$$VS^0(\otimes)=\begin{pmatrix}1\\0\\0\\1\end{pmatrix}. \qquad (1)$$

The polarization properties of the optically anisotropic (Δn is the linear birefringence index LB) protein fibril (with geometric size d and spatial orientation of the optical axis ρ) in the volume of the polymers samples correspond to the Mueller matrix birefringence operator

$$\{W\}_j=\begin{pmatrix}1 & 0 & 0 & 0\\ 0 & \omega_{22} & \omega_{23} & \omega_{24}\\ 0 & \omega_{32} & \omega_{33} & \omega_{34}\\ 0 & \omega_{42} & \omega_{43} & \omega_{44}\end{pmatrix}_j=$$
$$=\begin{pmatrix}1 & 0 & 0 & 0\\ 0 & (\cos^2 2\rho+\sin^2 2\rho\cos\delta) & (\cos 2\rho\sin 2\rho(1\;\;\cos\delta)) & (\sin 2\rho\sin\delta)\\ 0 & (\cos 2\rho\sin 2\rho(1\;\;\cos\delta)) & (\sin^2 2\rho+\cos^2 2\rho\cos\delta) & (\cos 2\rho\sin\delta)\\ 0 & (\sin 2\rho\sin\delta) & (\cos 2\rho\sin\delta) & (\cos\delta)\end{pmatrix}_j. \qquad (2)$$

Here $\delta=\frac{2\pi}{\lambda}\Delta nd$ — phase shift between linearly orthogonally polarized components of the laser beam amplitude; λ — wave length.

The process of local (i – th) single transformation by a local polymer fibrillation (ρ_j; δj) of the polarization structure of the probing beam $S^0(\otimes)$ is described by the following matrix equation

$$VS_i^*(\alpha_i,\beta_i)= \\ =\{W\}_i VS^0(\otimes). \qquad (3)$$

As a result, a partial laser wave is formed with the following azimuth α_i and β_i ellipticity of polarization

$$\alpha_j=0.5\arctan\left(\frac{VS_3^*}{VS_2^*}\right)= \\ =0.5\arctan(\text{cotan}2\rho_j)\equiv \\ \equiv q(\rho_j); \qquad (4)$$

$$\beta_j=0.5\text{arcin}\left(\frac{VS_4^*}{VS_1^*}\right)= \\ =0.5\text{arcin}(\cos\delta_j)\equiv \\ \equiv g(\delta_j). \qquad (5)$$

Here $VS^*_{i=1;2;3;4}$ parameters of the Stokes vector of a single-scattered laser beam $VS_i^*(\alpha_j,\beta_j)$.

Thus, the component of the laser field, once scattered by the fibrillar polymer network, represents two polarization distributions:

— 'azimuthally-orientation' $\Lambda(\alpha_j;\rho_j)$;

— 'phase' $\Psi(\beta_j;\delta_j)$.

The wavelet analysis of a polarization-inhomogeneous field (relations (4), (5)) is based on an analytical transformation consisting in the decomposition of a distribution over a basis constructed from a soliton-like function (wavelet) by means of large-scale changes and transfers [6].

The continuous wavelet transforms of the function $\Phi(\alpha;\beta)$ is defined by the following formula

$$W(a,b)=\frac{1}{\sqrt{a}}\int_{-\infty}^{\infty} g(x)\cdot \\ \cdot\omega\left(\frac{x-b}{a}\right)dx, \qquad (6)$$

Where a is a scale parameter, b is a spatial coordinate, and ω is a soliton–like function (wavelet) constructed on the basis of derivatives of the Gaussian function.

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In our work, the second derivative ($m = 2$) or MHAT wavelet is used

$$\omega^{(m)} = (-1)^m \frac{\partial^m}{\partial x^m} \cdot \left[\exp\left(\frac{x^2}{2}\right)\right] \Rightarrow \omega^{(2)} = = \frac{\partial^2}{\partial x^2}\left[\exp\left(\frac{x^2}{2}\right)\right]. \quad (7)$$

The wavelet relations (6), (7) for polarization maps of azimuth and ellipticity of the scattered radiation field by diffuse layers of polymers can be written as the following expressions

$$\begin{cases} W^{\alpha}(a,b) = \frac{1}{\sqrt{a}}\int_{-\infty}^{\infty} A(\alpha,x)\omega\left(\frac{x-b}{a}\right)dx; \\ W^{\beta}(a,b) = \frac{1}{\sqrt{a}}\int_{-\infty}^{\infty} B(\beta,x)\omega\left(\frac{x-b}{a}\right)dx. \end{cases} \quad (8)$$

Wavelet differentiation of azimuth maps of polarization samples from Group 1 and Group 2

As an information component of the graphic image, we chose a network of birefringence cylinders ordered in the direction of the optical axes and located in the same plane.

The background component is a collection of birefringence balls whose centers lie in the same plane.

The geometric characteristics of the set ( ) of optically anisotropic cylinders are as follows: diameter — microns, length — microns. Birefringence —.

Optically anisotropic balls — with different diameters — d = 25 microns and 50 microns — object 1 and object 2, respectively.

Birefringence of balls —.

On the fragments of fig. 1 presents the results of an analytical wavelet analysis of $W(\omega_k, b)$ maps of the polarization azimuth $\alpha(\theta, m \times n)$ of a microscopic image of objects from group 1 and group 2.

From the obtained data, it was revealed:

— Scale-selective structuring of map wavelets of coefficients $W(\omega_k, b)$ of coordinate distributions of the polarization azimuth $\alpha(\theta, m \times n)$ of a microscopic image of objects from group 1 and group 2.

— Coordinate inhomogeneity of wavelet distributions of coefficients $W(\omega_k, b)$ maps of the polarization azimuth $\alpha(\theta, m \times n)$ of microscopic image of both types' samples.

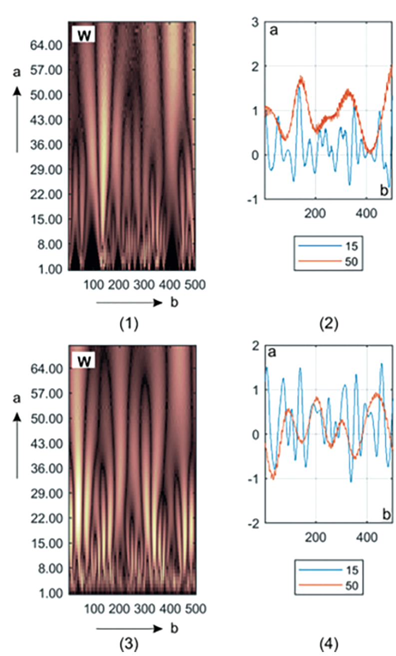

Fig. 1. Maps (left column) and multiscale linear cross-sections (right column) of wavelet coefficients ω_k distributions of the polarization azimuth $\alpha(\theta, m \times n)$ microscopic images of objects from group 1 and group 2

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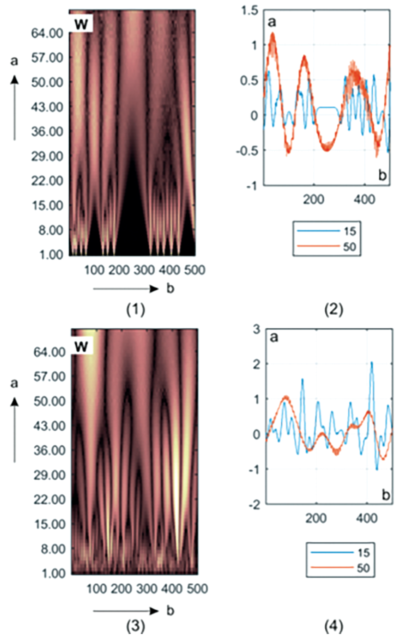

Fig. 2. Maps (left column) and multi-scale linear cross-sections (right column) of wavelet coefficients of distributions of the polarization ellipticity microscopic images of objects from group 1 and group 2

Wavelet differentiation of ellipticity maps of polarization samples from Group 1 and Group 2

On a series of fragments, fig. 2 the results of the application of the wavelet analysis technique $W(\omega_k, b)$ of another polarization parameter of the object field — maps of the ellipticity of polarization $\beta(\theta, m \times n)$ of the phase ($\theta = \pi/8$) microscopic image of histological sections of the myocardium of those who died due to CHD and ACI are presented.

Discussion

Analysis of the obtained results of the wavelet decomposition of maps of azimuth and ellipticity of polarization of graphic images on polymer Media revealed the analytical possibility of selecting multi-scale distributions of wavelet coefficients that separately describe the information and background components.

This technique can be used in further reverse reconstruction of multi-scale components of a graphic image.

Conclusions

1. The effectiveness of wavelet analysis of azimuth and ellipticity of polarization maps of graphical images was demonstraited.

2. Scenarios for the formation of coordinate maps of multi-scale wavelet coefficients, that characterize the distributions of the azimuth and ellipticity of the polarization of a repeatedly scattered object field of polymers layers are determined and physically justified, where the influence of the diffuse component is minimized.

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В статті розглянуто один з методів покращення якості графічних зображень за допомогою масштабно-селективного вейвлет аналізу. Проаналізовано нові оптичні та поляризаційні методи обробки графічних зображень з використанням масштабно-селективної вейвлет фільтрації для селекції інформаційної та фонової компонент.

Ключові слова: графічне зображення; лазер; вейвлет аналіз; інтенсивність світла; поляризація; цифрова камера.

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