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STATISTICAL IMAGE ANALYSIS FOR INFORMATION SYSTEM

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СТАТИСТИЧНИЙ АНАЛІЗ ЗОБРАЖЕНЬ ДЛЯ ІНФОРМАЦІЙНОЇ СИСТЕМИ

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The surface Kirchhoff integral is numerically calculated by the fourth-order Newton – Cotes method with high accuracy. The intensity is normalized. Implemented quantization of the signal with a unit step for different distances of observation is carried out. The cross section of the central topological object intensity and its characteristics are shown. Variation curves and cumulates are constructed for intensity distributions at different observation distances. The basic statistical parameters of distributions are determined, such as, the mode, the mean, the median and the standard deviation.

Keywords*: optical image, statistical analysis, information optical system*

Introduction. Information technology [1-3] is the broad subject concerned with all aspects of managing and processing information. It includes different levels — from the physical hardware to the operating systems, applications, databases, storage, servers etc. Database is set of independent materials, presented in an objective form and systematized in such a way that these materials can be found and processed using a computer. In the research laboratory usually a big volume of data is analyzed. The functions of automated measuring information optical system (AMIOS) include: data collection and analysis, storage and retrieval of information, protection and transmission of information on laser radiation characteristics. An optical image contains topological objects such as: maxima, minima and zeroes of intensity. Based on them we can define the systematization method for database creating. Computer science is focused entirely on efficiently programming computers using mathematical algorithms.

Calculation of data and its statistical analysis. The problem of passing laser beam through a set of optical elements can be solved by the Kirchhoff integral:

$$A(x_1, y_1, z) \sim \iint A_0(x, y)\exp(i\Phi_0(x, y) + \\ + if(x - x_1, y - y_1))dxdy \quad (1)$$

where $A_0(x, y)$ - initial amplitude in the plane of the diffraction element XY, $\Phi_0(x, y)$ - the initial phase in the plane of the diffraction element, $f(x - x_1, y - y_1)$ - the function of describing the diffraction phenomenon, which is observed at a distance *z* from the screen on the plane X_1Y_1 .The Kirchhoff integral is calculated numerically by Newton-Cotes formula of the closed type with high accuracy.

For the scalar light field an optical image has information parameters: beam intensity and phase; identifying parameters: wavelength of laser radiation, beam waste radius, initial distribution of phase and beam intensity; as well as the structural parameter - the image observation distance z from the exit window of the laser.

Let`s consider the intensity distribution for a quasi-plane wave (QPW) passing through a double-phase-ramp (DPR) converter at the distance of observation z=40cm (Fig. 1a). We normalize the received data for intensity, so that the maximum value is 255, which corresponds to the maximum value for experimental images obtained with a CCD camera. The next step is quantization of the data with a unit interval. The central segment (Fig. 1b) is taken from the initial image (Fig.1a) for more detailed analysis. The cross-section of this segment, which includes maxima and minima of the intensity is shown in Fig. 1c. The systematization method for database creating is based on coordinates of topological objects and their parameters, such as core ellipticity and angle of inclination. Sharp jumps on the curve (Fig. 1c) are stipulated by the image marking, placed for further determination of topological object parameters.

After this images are ready for implementation of statistical analysis methods. First of all, carry out a data grouping using the variation series [4-7], which shows how the numerical values of the intensity from 0 to 255 are related to their repetition. Variation curves (Fig. 1d) obtained at different distances are analogous to each other. The central part of variation curves is similar to the normal distribution with a positive excess. It has a high narrow peak, indicating the accumulation of frequencies in the middle, the typicality and reliability of the average value. The mean value I¯is calculated by the formula:

$$\bar{I} = \frac{\sum_1^N I_i}{N}, \qquad (2)$$

where I_i – the observed intensity in the i-th group N – the number of quantized intensities. The standard deviation σ represents the degree of scatter of data around the mean value and is defined by the

$$\sigma = \sqrt{\frac{\sum_1^n (I_i - \bar{I})}{N}}. \qquad (3)$$

In result, we get the following statistical values for the image at z=40cm: the arithmetic mean is 139, the mode is 141 and the standard deviation is about 48 are changed slowly with a distance.

Another one method of data representation is a cumulative curve. The cumulative curves for the intensity patterns are shown in Fig. 1e at different distances z. We want to emphasize that curve for smaller distance has a more expressive form, due to the fact that a light field decreases with the growing of observation distance. The point of lines intersection is determined the median, which is about 141.

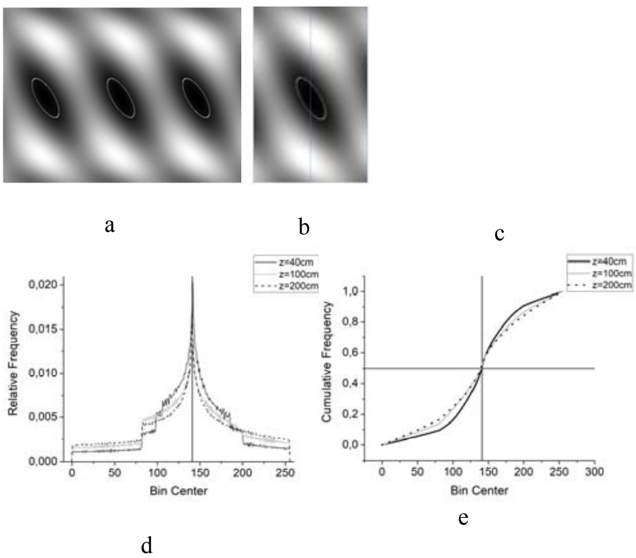

Fig. 1. Distribution of intensity in the diffracted field at the distance *z*=40cm (a), segment of intensity distribution for analysis (b), cross-section of distribution of intensity by line x = 0 (c), variance curves of the points number (d), cumulates (e) depending on the intensity for different distances

Conclusions. The statistical method is highly precise and effective for data analysis. The data obtained by the theoretical investigation of the diffracted field is performed by the surface Kirchhoff integral, which is numerically calculated, using the fourth-order Newton – Cotes method. The intensity is normalized and quantized with a unit step for different distances of observation. The cross section of the central topological object intensity and its characteristics are shown. Variation curves and cumulates are constructed for intensity distributions. The basic statistical parameters of distributions are determined, such as, the mode and the median from the graph, the mean and the standard deviation by calculations.

In the future, it is planned to investigate the structure of data and to check how consistent the obtained statistical descriptions of theoretical data are with experimental descriptions according to the Pearson and Kolmogorov consent criteria.

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References

1. M. Z. Zgurovsky, I. I. Kovalenko, V. M. Mikhailenko, Introduction to Computer Information Technologies, Teach. manual .- K .: View of the European Unitary Enterprise, 2002.- 265 p. ISBN 966-7508-74-9.
2. S. Yadav Foundation of Information Technology, New Age International Publisher; 3rd edition, 2006
3. V. Rajaraman, Introduction to information technology, Prentice hall India PVT., Limited, 2003, 384 p.
4. Alfalou, C. Brosseau Optical image compression and encryption methods. Advances in Optics and Photonics, 1, 2009, 589 p.
5. G. Nehmetallah, P. P. Banerjee Applications of digital and analog holography in three-dimensional imaging. Advances in Optics and Photonics, 4, 2012, 472–553 pp.
6. G. Upton, I. Cook Introducing Statistics, Oxford University Press, 2001. 235 p.
7. V.V. Luneev, Legal Statistics. 2nd ed., Rework and addition, with change - M .: Lawyer, 2007. - 394 p. ISBN:978-5-91768-088-0

Рязанцев А.О., Хорошун Г.М., Рязанцев О.І.
Статистичний аналіз зображень для інформаційної системи

Поверхневий інтеграл Кірхгофа чисельно розраховується за допомогою методу Ньютона-Котса четвертого порядку з високою точністю. Нормалізується інтенсивність. Реалізовано квантування сигналу з одиничним кроком для різних відстаней спостереження. Показані перетини інтенсивності центрального топологічного об'єкта і його характеристики. Варіаційні криві і кумуляти побудовані для розподілів інтенсивності на різних відстанях спостереження. Визначаються основні статистичні параметри розподілів, такі як мода, середнє значення, медіана і стандартне відхилення.

Ключові слова: *оптичне зображення, статистичний аналіз, інформаційна оптична система*

Рязанцев А.А., Хорошун А.Н., Рязанцев А.И.
Статистический анализ изображений для информационной системы

Поверхностный интеграл Кирхгофа численно рассчитывается с помощью метода Ньютона-Котса четвертого порядка с высокой точностью. Нормализуется интенсивность. Реализовано квантование сигнала с единичным шагом для разных расстояний наблюдения. Показаны сечения интенсивности центрального топологического объекта и его характеристики. Вариационные кри-

вые и кумуляты построены для распределений интенсивности на разных расстояниях наблюдения. Определяются основные статистические параметры распределений, такие как мода, среднее значение, медиана и стандартное отклонение.

Ключевые слова: *оптическое изображение, статистический анализ, информационная оптическая система*

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