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SPATIAL AND FREQUENCY DESCRIPTIONS, POWER SPECTRUMS TO THE ANALYSIS OF PARAMETERS OF IMAGES OF FLIGHT INFORMATION

The present article the authors analyzed the status and relevance of a model close to the real through the use of mathematical tools of game theory and operations research to assess the imaging parameters crewflight information displays for civil aircraft. The authors examined the mechanism of interaction between different components of a single process of testing the readiness of civil aircraft in flight, as factors of influence on the perception of human visual flight information.

Analysis of the last researches, the decision of problem of intercommunication of effects, which are investigated for perception of high-quality flight information a crew on displays in the booth of airplane with application of CALS and their influence on quality of images [1] consists in that which is considered impossible decision of problem of optimum of process of analysis unassisted development of modern positions of theory, is founded in which.

The problem is to study the relationship of various characteristics of the images and their impact on the quality of flight information displays for aircraft cabins [1] using CALS-technologies. In the process of experiments on a designing complex will assume that an image is characterized by a two-dimensional function $\xi(x,y)$, then for the small on sizes area of image areas on the cabin display of kind, in,x,$x+\Delta x$, $y+\Delta y$ it is suggested to find a function

$$F_{xy}(\omega_x,\omega_y)=\frac{1}{2\pi}\int_{x}^{x+\Delta x}\int_{y}^{y+\Delta y}\xi(x,y)e^{-j(\omega_x x+\omega_y y)}dxdy\ , \quad (1)$$

A function $F_{xy}(\omega_x, \omega_y)$ will name a local spatial two-dimensional image, which shows, with which specific gravity to summarize spatial signals in an order to get an initial signal $\xi_{xy}(x,y)$ in the noted area of image. By a local spatial two-dimensional $F_{xy}(\omega_x, \omega_y)$ the signal of image is determined by reverse transformation of Fourier

$$\xi_{xy}(x,y)=\frac{1}{2\pi}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}F_{xy}(\omega_x,\omega_y)e^{j(\omega_x x+\omega_y y)}d\omega_x d\omega_y\ , \quad (2)$$

where ω_x and ω_y - named circular spatial frequencies.

The signals of image are proportional to linear spatial frequencies υ_x and υ_y (taking into account a coefficient 2π). Naturally, that the different areas of image of flight information on displays in the booth of airplane can have different functions $F_{xy}(\omega_x, \omega_y)$. Than anymore a size changes$\xi(x,y)$ within the limits of the considered area, the area of spatial frequencies, in which a function $F_{xy}(\omega_x, \omega_y)$is substantially different from a zero, becomes wider. An area of existence of local spatial spectrum will be the wider, than any more on this area meets shallow details or than higher level of the signal of image processing. If in the formula (2) of integration to carry out an image within the limits of all plane, that summarizeall values of local spatial spectrums, then will get the so-called two-dimensionalspatial (general or integral) spectrum of all image of flight information on displays in the booth of airplane

$$F(\omega_x,\omega_y)=\frac{1}{2\pi}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\xi(x,y)e^{-j(\omega_x x+\omega_y y)}dxdy\ , \quad (3)$$

From expression (3) to reverse transformations of Fourier [6] will pick up thread the function of signal $\xi(x,y)$of all image. Decision of a number of tasks to the analysis of local and general two-dimensionalspatial spectrums of images it appears useful enough. That, at the analysis of images in linear processes, their influence on a signal is simpler determined in spectral presentation, what at research of changes of signal. A linear process can be described spatially frequency by description, that allows by simple correlation to link the frequency spectrums of entrance and initial (in relation to a process) signals of image spatially.

A research purpose is upgrading of perception of images on the displays of airplane taking into account influence of descriptions of displays, equipment of visualization and intercommunication of descriptions of the lighted up flight information on displays in the booth of airplane.

New approach for the decision of problems consists in that in our raising of task by analogy with determination of local two-dimensional spatial spectrum of image will enter the concept of local two-dimensional power spectrum [1]

$$S_{xy}(\omega_x, \omega_y) = \left|F_{xy}(\omega_x, \omega_y)\right|^2 . \qquad (4)$$

The proper method from expression (4) is determine the power spectrum of all image (as a sum of local power spectrums of all areas of image). Physical maintenance of power spectrum of image is related to relative energy which carries in itself the signal of image on unit of area of image (therefore more faithful to name his spectrum powers or by the spectral closeness of power) in the interval of frequencies ω_x–$\omega_x+\Delta\omega_x$, ω_y–$\omega_y+\Delta\omega_y$. So, for example, if a function $\xi(x,y)$ is a size, which determines light streams which emanate different parts of image, then functions $S_{xy}(\omega_x, \omega_y)$and $S(\omega_x, \omega_y)$is the frequency distribution of specific values of spatial power of these light streams on the range of spatial frequencies accordingly for a local area and all image.

A scientific result consists in the following: it is experimentally set, if in the process of design to conduct the analysis of information on the power spectrum of primary function $S(\omega_x, \omega_y)$by reverse transformations of Fourier, then by analogy with a formula (4) obsessed quadratic description of signal of image, and by reverse transformation of Fourier get the autocorrelation function of image

$$R(x, y) = \frac{1}{2\pi} \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} S(\omega_x, \omega_y) e^{j(\omega_x x + \omega_y y)} d\omega_x d\omega_y . \qquad (5)$$

An autocorrelation function can be certain both for the area of image and for all image on the whole. For final functions $\xi(x,y)$ middle statistical descriptions of which do not depend on the order of their adding up, the operation of transformation of autocorrelation function is simplified, because $R(x,y)$ the not co-ordinates of pixel are taken into account in expression, but only their difference. For one-dimensional presentation of signal of image an autocorrelation function can be certain as

$$R(\lambda) = \frac{1}{L} \int_0^L \xi(l)\xi(l+\lambda)dl , \qquad (6)$$

where$L$ - is length of involute of all image.

As an autocorrelation function is quadratic description, it is always positive and diminishes on a size with growth λ. At $\lambda \to L$, $R(\lambda)$ aspires the mean value of size to the square ξ. At $\lambda = 0$

$$R(0) = \overline{\xi} = \xi^2 + \sigma_\xi^2 , \qquad (7)$$

where $\xi(l) = \overline{\xi}$. $R(0) - R(\infty) = \sigma_\xi^2$ - characterizes part of power, related to the rejections of size, that is why it it is suggested to name variable component power of signal of image.

Thus, $R(\infty) = \overline{\xi^2}$ answers permanent component power of signal of image. As $R(0)$ equals a sum permanent and variable component powers, it determines complete power of signal of image. In an order to get more universal description which does not depend on concrete values $\overline{\xi}$and σ_ξ^2, it is possible to pass from the function of autocorrelation to the coefficient of autocorrelation

$$r(\lambda) = \frac{R(\lambda) - \overline{\xi^2}}{\sigma_\xi^2} . \qquad (8)$$

If a function$R(\lambda)$ changes from complete to permanent component power of signal, then $r(\lambda)$changes from 1 to 0. Transition from the function of autocorrelation to the coefficient of autocorrelation equivalent to replacement of power spectrum$S(\omega)$ the rationed power spectrum $S(\omega)/S(0)$.

Exposition of basic material of research. For description of frequency and power spectrums different numerical parameters are entered, for example maximum frequency of spectrum, coefficient of autocorrelation which is a function from λ. Therefore the autocorrelation function of image $R(\lambda)$can be characterized by an integral to autocorrelation λ_0. An interval of autocorrelation is the parameter of estimation, which determines the local or general for all image sizes of distances, which display elements are highly enough correlated at. For determination of interval of autocorrelation arbitrary suppositions are accepted. More frequent all the interval of autocorrelation is set at minimum values r_{min}, accepted here, that at $r<r_{min}$ intercommunication of display elements is unimportant. Than anymore interval of autocorrelation, the more so interdependent display elements. Sometimes for finding more comfortable to use other assumption, which a width of rectangle (with a height even of unit) the area of which equals an area under a curve is at. In this case an integral λ_0 is determined by the equivalent integral of reliable cross-correlation connection.

The first method of determination λ_0 is any more comfortable for practical realization of tasks on measuring of cross-correlation intercommunications of display elements, and the second method of determination λ_0 - for his theoretical analysis. Under effective maximum frequency of power spectrum ω_n will be to understand the width of such even spectrum in which complete power equals complete power of this concrete spectrum

$$\omega_n = \frac{1}{S(0)} \int_0^{\infty} S(\omega) d\omega \quad . \tag{9}$$

Experimental researches rotined in the process of design, that the autocorrelation functions of brightness of flat images were well enough approximated on the average by exponential dependence

$$r(\lambda) = e^{-q\lambda} \quad , \tag{10}$$

where q - is a constant the size of which depends on the type of image.

After numeral mathematical transformations obsessed results of design of process of picture of displays necessary generation for high-quality perception by the crew of flight information. It is set, in the images of flight information on displays in the aircraft cabin is no clear enough orientation in some certain direction and next transformations of images is produced, mainly, in the optical and electron-optical systems with application of izotropic materials of display. Dvomirniy power spectrum of izotropic image in arctic co-ordinates at exponential to the autocorrelation function looks like

$$S(\omega_n) = \frac{q_p}{\sqrt{2\pi}(q_p^2 + \omega_p^2)^{3/2}} , \tag{11}$$

whereq_p - is a constant the size of which depends on distance between pixels.

For images, which have a coefficient of autocorrelation as експонентної function (11) and the rationed power spectrum (12), interval of autocorrelation $\lambda_0$and effective maximum frequency ω_n, depend only on the co-ordinate q

$$\lambda_0 = \frac{1}{q}; \qquad \omega_n = \frac{\pi}{2} q \tag{12}$$

On (Fig. 1) the graphic arts of coefficients of autocorrelation of four colors of flight information are resulted on displays in the booth of airplane, measured by an optical correlometer. The coefficient of correlation of the objective measurings and subjective estimations appeared observers even *0,98*. Therefore in future we will use a term rizkistna characteristic image, meaning all autocorrelation function (or power spectrum) of image hereunder, including, as one of its important parameters is a value of derivative coefficient of autocorrelation at the beginning of co-ordinates q. The size $q$depends on frequency maintenance of image, in particular from specific gravity in him sharp changes of brightness, shallow details, and also from description of previous processes of transformation of image of flight information on displays in the booth of airplane. It is suggested also to get the function of closeness of distributing of parameter q. Zero values q answer the base-line areas of image, maximal values $q_{loc.max}$ are arrived at in those areas, where the signal of image has maximal changes. On an interval $0 - q_{loc.max}$ the general beds for all image q_{int} (local integral coefficient), which probably, near to the mean value $\overline{q_{loc}}$, but does not equal him, because specific gravity of base-line areas is on images, as a rule, high enough. Thus the coefficient of autocorrelation is obtained by character of function of discrete argument, multiple element of spatial

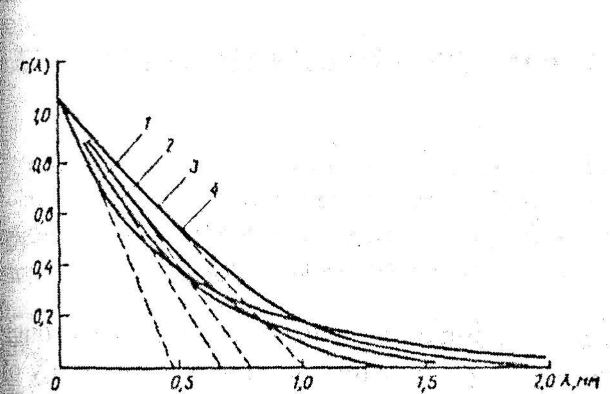

Figure 1. Autocorrelation coefficients of the four primary colors for flight information.

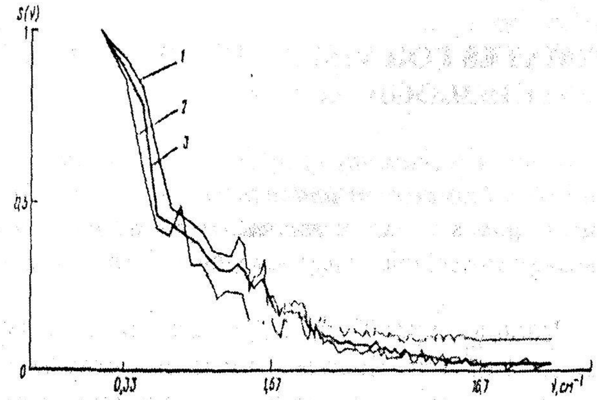

Figure 2. Results of a typical energyspectrum of color flight information.

discretisation of signal ($n \cdot \Delta l$), where n=1,2,3 . At determination of size$r_{инф}(n \cdot \Delta l)$ the informative areas of image must correlate with the signal of n by the base-line areas of the proper level of quantum.

Confirmation of justice of assertions in-process is an analysis of additional parameters of research, which were used for a design. It is set that the values of local coefficient q_{loc} are different from general (integral) for all image q_{int}. At presence of a few (two or three) plans the greatest value q_{loc} as a rule, have areas of image of basic, main plan. If hypothetically to present, that measuring of local coefficient of autocorrelation is carried out on the small enough for areas area of image, then will answer every image weeds local coefficients of autocorrelation restrictedly from above $r(\lambda) = 1$, and from below by a curve $r_{\min}(\lambda)$ (Fig. 2).

Conclusions

Prospects of subsequent researches in scientific subdirection of processing of images consist in that it is first offered untraditional going near the decision of problems of analysis of images of cabin displays. It allows to execute more exact calculations at planning of displays. Practically, more comfortable to figure on by the previous record of discrete and quantized signal with the next including of algorithm of delete of base-line and cropping areas of information. The values of coefficient of autocorrelation are certain by such method will appear considerably less on a size, what got in regular fashion. A priori it is possible to assume that autocorrelation and proper to them power descriptions of signal of image will be more closely associated with the visual estimation of rizkistnyh parameters of image of flight information on displays in the booth of airplane, what generally accepted in the theory of casual processes of function.

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