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Abstracts

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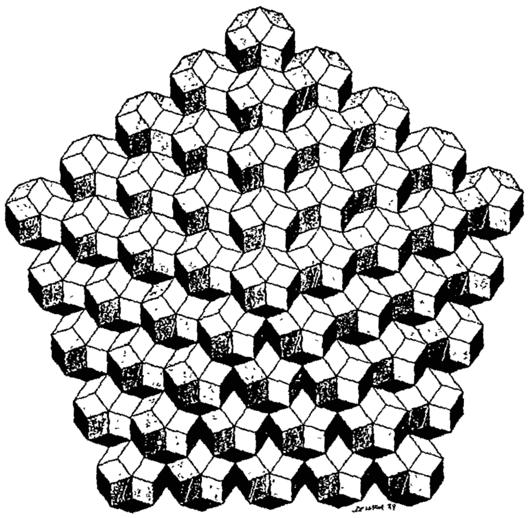

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THE USE OF SYMMETRY PRINCIPLES IN THE COMPUTER MICROTOMOGRAPHY AND IN THE DIAGNOSTICS AND DEVELOPMENT OF NEW METHODS OF INFORMATION PROCESSING AND OBTAINING

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The use of the Computer Microtomography (CM) Methods for diagnostic purposes demanded a wide use of the general symmetry principles under the development and designing either of the hardware or of the software of a Microtomography unit The high needed resolution level (1-10 micrometers) of the CM unit and also the application of standard sources of scanning radiation and the detector complexes, as a rule, lead to considerable scanning times, during which in a number of cases it is difficult to provide the demanded functioning stability of the sources electronic and detecting complexes. The consideration of pecularities of their long-time work, as a rule, is provided by the software means, what from its side leads to the increase of complexity of the CM software and to the rise of the corresponding demands for the resources and productivity of the software, and correspondingly of their prices. On the other hand, the scanning process time comes sometimes in the contradiction to the demands on the complex productivity under the use of the Microtomograph in the product quality control systems.

The application of Symmetry Principles under the processing of the shadow function measurement results allows to realize new regimes of scanning: the stretch regime and the regime of more detailed analysis of the found zone of suspicion. On the other hand, such an approach allowed to develop a new method of shadow function analysis, based upon the calculation of spacial moments.

In the CM among a variety of different problems there are two main calculation problems which take a particular place. The first of them is to reconstruct the shadow function of the spacial variables $f(x-y)$ in accordance with the results of an indirect experiment, representing itself projections of the function $f(x+y)$ along a set of straight lines. The second problem is connected with the analysis and classification of the function $f(x+y)$ on the basis of the same projection data

These problems are being solved nowdays independently one from another. However we can consider them in a complex The basis for it can serve the fundamental theorem of Hu, according to which the display function $f(x-y)$ is in a one-to-one connection (through the characteristic function) with an infinite number of its moments $\{m_{\alpha\beta}\}$. The moment of the $(\alpha+\beta)$ -order is defined in the following way

$$m_{\alpha\beta} = \int_{-\infty}^{+\infty} x y\beta - (x,y)\,dx\,dy \qquad (1)$$

Consequently the set of moments $\{m_{\alpha\beta}\}$ of the function $f(x-y)$ can serve as the initial data for the reconstruction algorythm of this function. On the other hand, this set of moments can be used as a system of secondary signs for the analysis of the function $f(x,y)$ with the application of the image recognition methods. It is worth to mark that the sign-moments have recieved wide practical application.

To the advantages of this method we can correspond primarily the fact that the ansamble of moments of this function of different orders can be easily increased, and the probability of the right discovery of deviations from symmetry rises along with the growth of body (power) of moments, used in the recognition processes. Under the use in a microtomograph, for example, of the Röntgen radiation there exists a possibility to calculate directly from the measurement results the spacial moments from the function, desribing the object under study, not recieving before this directly the tomogramm itself. This fact can be rather useful in the cases when the problem is reduced only to the control of symmetry of the object. Excluding from the control processes of the tomogramm reconstruction stage we can succeed to reduce the scanning time of the object considerably. The realized approach allowed in general to reduce the processing time of the controlled good from 45 to 80% depending on the type of the good and the level of the demanded resolution and also to transfer to the complex usage of possibilities of the CM. In this case the detailed analysis of the suspicion zone allows to obtain the complete information on the character of defects and their geometrical characteristics which allows together with the functioning of the purposeful software which describes the life cycle in the predictable and non-predictable situations, and also the evolutions of the defect parameters during this time, to forcast sufficiently exactly the working resources of the good to reconstruct the technology of its production and repairing. It is important to note that under the analysis of concrete technical parameters of the goods, including the analysis of shadow functions, the demand for symmetry is to be sensibly interpreted, because the results of every measurement are defined by a large number of factors, which means that mathematically the problem is reduced to the correct reduction of a function, depending on a large number of variables, to a function, which describes sufficiently exactly the regulations, but depending on a smaller number of variables.

The main problem of approximation in its classical formulation is stated in the following way On a certain point set M in the space of arbitrary number of changes two functions $f(P)$ and $F(P, A_1, \ldots, A_n)$ of the points PAM are given. The second of them depend also from a set of parameters $A_1, \ldots, A_n$. These parameters are to be found in such a way that the deviation in M of the function $F(P, A_1, \ldots, A_n)$ from the function $f(P)$ under the deviation F from f. It is worth to be mentioned that modern methods of the applied mathematics and the computer techniques allow to solve practically any problem of the approximation in the classical formulation if the class of approximation functions is given - F and the type of deviation. And how shall we do in the case when the class of approximation functions is not given ?

If we speak about the function $F(P)$, depending on a single variable, then the choice of the class of approximation functions (the empirical formulae) F with the help of geometrical interpretation (the graphical analysis) doesn't meet any difficulties For this case there exists a number of guidelines. The question of the choice of the suitable class of approximating functions, if there are not sufficiently reliable theoretical considerations, is sharply complicated, when we study the functions of three (sometimes two) or more variables.

We have elaborated a method which allowed to reduce the analysis of functions of many variables to the analysis of functions of a smaller number of variables and simultaneously to construct the approximation function. This method of approximation of a a function of many variables by a superposition of summs of functions of a smaller number of variables gives in the parallelepiped $\mathcal{D} = \{a_i \leq x_i \leq b_i,\ i = \overline{1,n}\}$ the approximation in the form $\varphi = (x_1, \dots, x_n) \approx \mathcal{L}\{\sum_{i=1}^{m} f_i(x_{i_1}, \dots, x_{i_g})\}$, where $\varphi(x_1, \dots, x_n)$ – the approximating function, depending on independent variables, $\mathcal{L}$ – a certain beforehand unknown function such that the inverse function for it is a polynom of the k-th order, i.e. if $y = \mathcal{L}(x)$ then $\mathcal{L}^{-1}(y) = \sum_{i=1}^{k} \alpha_i y^i$, $f(x_{i_1}, \dots, x_{i_g})$ is a certain beforehand unknown function from a definite combination of variables, the number of which is smaller than n.

The realization of this method on a computer allows to find functions $\mathcal{L}^{-1}$ (and consequently $\mathcal{L}$) and $f(x_{i_1}, \dots, x_{i_g})$, which give a minimum of the expression relatively to the middle square deviation.

The joint use of the described approaches allows to provide high indexes in the practice of realization of tomography systems.

The questions of diagnostics of electronic equipment components (chips, multi-layered printed surfaces etc.) become even more actual in connection with a wider use of the electronic equipment and computer techniques in different branches Within the frameworks of the realization of a number of scanning devicea for quality control, including the methods of CM, described above, we have widely used the symmetry principles, based on a comparative analysis of the parameters of ethalon systems and diagnostized systems. Under the realization of such an approach the creation of ethalon systems are possible in two ways, one of which consists in the obtaining and fixation of the processed signals of detectors, recieved as a result of scanning of non-defectable good, and the second in the obtaining and use of specially developed methods of numerical modelling of scanning processes, for example, the Monte-Carlo methods for the three-dimensional models of scanning cells taking into account the pecularities of work and spectral characteristics of the scanning radiation source of the detecting complex and the pecularities of evolution of the scanning beam characteristics under its passage through the object.

In particular, for the problems of beam tomography and primarily the Röntgen tomography a complex mathematical model has been developed for a scanning complex, consisting of a radiation source and the collimating system, the scanning object and a detector, which also has a collimating system

We have considered a stationary equation of the transfer of photons in non-uniform medium in the form

$$\vec{\Omega}\cdot\nabla\Phi(\vec{r},E,\vec{\Omega})+\Sigma(\vec{r},E)\cdot\Phi(\vec{r},E,\vec{\Omega})=$$
$$=\int K(\vec{r},E'\to\vec{\Omega}'\to\Omega)\cdot\Phi(\vec{r},E',\vec{\Omega}')dE'd\vec{\Omega}'+Q(\vec{r},E)$$

where $\Sigma(\vec{r},E)$ - the complete macroscopic section of interaction of a photon with the medium; $K(\vec{r},E'\to\vec{\Omega}'\to\Omega)$ - the differential section of photon scattering, $Q(\vec{r},E)$ - a function, describing the photon source; $\Phi(\vec{r},E,\Omega)$ - a differential flux in a point of phase space $(\vec{r}\ E\vec{\Omega})$ which was solved by the Monte-Carlo methods in the multi-group transport approximation for a three-dimentional model.

As our experience showed, the second approach allowed to use widely different additional possibilities of classification and discovering of defects in the microelectronic items Obviously, the use of such principles is possible in the other branches of diagnostics.

Thus the wide use of symmetry principles in the CM and the diagnostics leaded to the nesessity of the development and creation of complexes of new methods of obtaining and processing of information.