

The Computer Diagnosing of Technical Objects with the Use of Pattern Recognition Principles

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Abstract – In the current article, the reasons are find out why computer diagnostics of technical objects by traditional algorithms does not work correctly. The new approach is offered on how to form a diagnosing algorithm by using the theory of pattern recognition. The recognition models as part of diagnosing algorithm may be built on the base of analytic forms. This results in efficiency algorithms, especially in test procedures. Incorrect mathematical forms are avoided in calculation operations. This allows getting able-bodied computer diagnosing programs for technical objects with checking and diagnosing systems, which operate automatically.

Keywords – Algorithm, control, diagnostics, simulation model, technical object.

I. PROBLEM ANALYSIS AND TASK SUBSTANTIATION

Improving of technical object computerized automatic control system is related to computer software algorithms. In [2] it was shown that the traditional identification models based on conventional arithmetic equation solutions were not effective because computing operations could be described mathematically as incorrect, difficult to implement for in-depth technical object position diagnosing. In each moment in time (t_1, t_2, \dots), the current state of the technical object identification control and management systems of traditional mathematical models is based on the arithmetic equation solutions:

$$Ly + Vx = y(t) \quad t \in (t_1, t_2, \dots, t_r) \quad (1)$$

$$Vx = \sum_{j=0}^{m-1} \alpha_j \cdot x [t - (m-j) \cdot T];$$

$$Ly = \sum_{j=0}^{n-1} \beta_j \cdot y [t - (n-j) \cdot T]$$

$$\bar{\theta} = U^{-1} = \begin{bmatrix} \alpha \\ \beta \\ \xi \end{bmatrix}$$

$$U = [X \ Y] \quad (2)$$

The vector $\bar{\theta}$ is an abstract set of values that cannot be used for diagnosis and in [2] it is shown how it is related to the transformation of the object function (TF) by using the simulation model of discrete operators $D_M(z)$ [3].

$$D_M(z) = f(W(p)) \quad (3)$$

$$\bar{\theta} \in D_M(z) \quad (4)$$

However, there is no workable algorithm TF $\hat{W}(p)$ for obtaining the vector $\bar{\theta}$ (2), while (3) and (4) analytical link appears in its indirect characteristic form. Thus, the diagnostic algorithm can be made on the basis of separation model that will be able to restore TF $\hat{W}(p)$ type based on the analytical relationships and links that cannot be determined. Weierstrass compatibility theorem allows defining the object property field in analytical form, confirming that any continuous function given interval can be replaced by an analytical expression. The author of the research report [1] has proven that the chosen model identification features of Weierstrass best meets the requirements of interoperability theorems. Thus, it is possible to form a recognition model based on (3) and (4) analytical cross-linking. For system of equation (2), solution operator $D_M(z)$ is expressed as the fraction of two polynomial functions:

$$D_M(z) = \frac{R_M(z)}{B_M(z)} = \frac{y(z)}{x(z)} \quad (5)$$

linked by a series of quantum signals

$$x(t) \Rightarrow \Phi z(T) * x(t) \Rightarrow \{x(iT)\}$$

$$y(t) \Rightarrow \Phi z(T) * y(t) \Rightarrow \{y(iT)\} \quad (6)$$

From (5) it follows that:

$$y(z) \cdot B_M(z) - x(z) \cdot R_M(z) = 0 \quad (7)$$

which is directly related to (1).

II. MODEL OF THE OBJECT STRUCTURE

The identification model is considered when the squarewise impulses are applied to the input. System (1) is active when the input signal is zero.

Then, (7) can be expressed as follows:

$$L(z) = y(z) \cdot B_M(z) \tag{8}$$

It is autoregression function and each part of equation (1) can be written as a vector multiplication

$$L(t_0) = \bar{y}^T(t_0) \cdot \bar{\xi}^T, \tag{9}$$

where: $\bar{\xi}$ - characterizing polynomial;

$$B_M(z) \in D_M(z);$$

$\bar{y}^T(t_0)$ vector of the coefficients in the T interval from the time t_0 .

$$\bar{y}^T(t_0) = y(t_0); y(t_0 + T); \dots y(t_0 + nT) \tag{10}$$

The space of Y properties form a vector (10) to the image space Ω from the characteristic vectors

$$\bar{\xi} \in D_M(z) \quad \bar{\xi} \in \Omega; \quad \bar{y}(t_{i0}) \in Y \tag{11}$$

In the image recognition model, an addition characteristic can be introduced that describes structural damage of the object. This may require the transformation functions $W(p)$ degree or pole sign change that will change the size of the vector multiplication. This property can be used for technical objects of structural damage identification. This can be demonstrated by the Laplace transformation of output signal.

$$Y(p) = Yw(p) + Yx(p) \tag{12}$$

When in the technical objects there are not structural damage multipliers (9) that meet the polynomial $B_M(z)$ and their components, the original will be a function of time in interval $t^{(n)} \in (t_0 \dots (t_0 + nT))$ and vectors (10) may be written as follows:

$$Yw(t) = \sum_{i=1}^{nW} Aw_i \cdot \exp(-a_i t); \tag{13}$$

$$Yx(t) = \sum_j^{nX} Ax_j \cdot \exp(-c_j t) \tag{14}$$

$$Yw(kT) = \sum_{i=1}^n Awy_i \cdot \exp(-a_i kT);$$

$$Yw(kT) \sum_i^n Awy_i \cdot \beta w_i^k; \tag{15}$$

$$Yx(kT) = \sum_{i=1}^n Awx_i \cdot \exp(-c_i kT)$$

$$Yx(kT) = \sum_i^n Awx_i \cdot \beta x_i^k;$$

$$\beta x_i = \exp(-c_i T) \tag{16}$$

Sum (12) corresponds to the sum of elementary fraction resulting from dividing multiplication $W(p) \cdot x(p)$.

Then vector

$$\overline{yw(t_0)^{(n)}}^T = [yw(t_0)yw(t_0+T)\dots yw(t_0+nT)] \tag{17}$$

may be written as follows:

$$\overline{yw(t_0)^{(n)}}^T = \sum_{i=1}^{nW} Aw_i \cdot \exp(-a_i t_0) \cdot \beta w_i \tag{18}$$

From (13), we obtain

$$\overline{yw(t_0)^{(n)}}^T = \sum_{i=1}^{nW} Aw_i \cdot \exp(a_i t_0) \cdot \beta w_i^k \tag{19}$$

$$B_M(z) \in D_M(z); \beta w_i^m \in B_{M_i} \tag{20}$$

Changing the sum order, expression (20) can be written as follows:

$$Ly(t_0) = \sum_{i=1}^{nW} A_i \cdot \exp(-a_i t_0) \cdot [1 \quad \beta w_i \quad \beta w_i^2 \quad \dots \quad \beta w_i^{nW}] \bar{\xi}^{(nW+1)} \tag{21}$$

Here

$$\bar{\xi}^{(nW+1)} = \sum_{i=1}^{nW} [\exp(-a_i t_0) \cdot A_i] \cdot (\beta w_i^T \cdot \bar{\xi}^{(nW+1)}) \tag{22}$$

By noting that

$$B(z) = \prod_{i=1}^{nW} (z - \beta w_i) = \sum_{i=0}^{nW} \xi_i \cdot z^{nW-i} \tag{23}$$

$$\bar{\xi}^{(nW)T} = [\xi_0 \quad \xi_1 \quad \xi_2 \quad \dots \quad \xi_{nW}] \tag{24}$$

One can match

$$[1 \quad \beta w_i \quad \beta w_i^2 \quad \dots \quad \beta w_i^{nW}] \cdot \bar{\xi}^{(nW+1)} = B(z) \tag{25}$$

$$B(z = \beta w_i) = \prod_{j=1}^{nW} (\beta w_i - \beta w_j) \quad (26)$$

After increasing equation (22) into (21), the reset can be written as follows:

$$Ly(t_0) = \sum_{i=1}^{nW} \exp(-a_i t_0) \cdot A_i \cdot \prod_{j=1}^{nW} (\beta w_i - \beta w_j); \quad (27)$$

From (27) it follows that:

$$Ly(t_0) = 0; \quad \beta w_i = \beta w_j; \quad (28)$$

$$\beta w_i \in \bar{y}(t_1 \dots t_N); \beta w_j \in D(z)$$

If there is no structural damage of the technical object, space orthogonal properties can be used:

$$\bar{y}(t_0)^T \cdot \bar{\xi}^{(n)} = 0; \quad \bar{\xi}^{(n)} \in D_{M_i}(z) \quad (29)$$

Thus, as the second component (13) we obtain:

$$Lx(t) = \sum_{i=1}^{nW} \exp(-c_i \cdot t) \cdot (Ax_i \cdot \prod_{j=1}^{nX} (\beta x_j - \beta w_i)) \quad (30)$$

III. EXAMPLE OF IMITATION MODEL DIAGNOSTICS

The model that has the transformation function is considered

$$W^{(6)}(p) = \prod_{i=1}^3 \frac{\tau_i p + 1}{[(p - a_i)^2 + \omega_i^2]} \quad (31)$$

The object consists of three elements, and its response to a single impulse is as follows:

$$y(t) = \sum_{i=1}^3 A_i \cdot \exp(a_i t) \cdot \sin(\omega_i t) \quad (32)$$

Information on the operator (31) is provided in the form:

$$\bar{A} = \begin{bmatrix} A_1 \\ A_2 \\ A_3 \end{bmatrix} \quad \bar{a} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} \quad \bar{\omega} = \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix} \quad (33)$$

The characteristic polinom $W(p)$ is:

$$W^{(6)}(p) = \frac{R(p)}{Q^{(6)}(p)}$$

$$Q^{(6)}(p) = [(p - a_1)^2 + \omega_1^2] \cdot [(p - a_2)^2 + \omega_2^2] \cdot [(p - a_3)^2 + \omega_3^2] \quad (34)$$

The corresponding polynomial of operator $B^{(6)}_M(z)$ of imitation model (5) is determined by the formulas examined in [2]:

$$B_M^{(6)}(z) = \prod_{i=1}^n [z^2 - 2ze^{-a_i T} \cos \omega_i T + e^{-2a_i T}] \quad (35)$$

$$B_M^{(6)}(z) = z^n + \beta_1 z^{n-1} + \beta_2 z^{n-2} + \dots + \beta_{n-1} z + \beta_n$$

Structural damage variations can be modelled by discrete polynomial $\bar{\xi}_i$ vectors of formula (34). Its diversity characterizes technical object structural damage according to the quantization period $T=0.1$ and they are summarized in Table I, where the numbering of the coefficients is associated with the combination numbers.

TABLE I
POLYNOMIAL $B^{(6)}(z)$, $N=4 \dots 6$ COEFFICIENTS

	$(B_1)^{\langle 2 \rangle}$	$(B_2)^{\langle 2 \rangle}$	$(B_3)^{\langle 2 \rangle}$	$(B_{12})^{\langle 4 \rangle}$	$(B_{13})^{\langle 4 \rangle}$	$(B_{23})^{\langle 4 \rangle}$	$B^{\langle 6 \rangle}$
$\beta_0 z^0$	0.819	0.449	0.247	0.368	0.202	0.111	0.091
$\beta_1 z^1$	-1.464	-0.414	0.307	-0.996	-0.11	0.036	-0.133
$\beta_2 z^2$	1	1	1	1.874	0.617	0.569	0.524
$\beta_3 z^3$	0	0	0	-1.878	-1.157	-0.107	-0.885
$\beta_4 z^4$	0	0	0	1	1	1	1.544
$\beta_5 z^5$	0	0	0	0	0	0	-1.571
$\beta_6 z^6$	0	0	0	0	0	0	1

Expression (9) should determine a phase shift between the space elements \bar{y} and $\bar{\xi}$, which is calculated by the formula:

$$\phi_i = \frac{\pi}{2} - \arccos \left\{ \frac{(y_i, \bar{\xi})}{\|y_i\| \cdot \|\bar{\xi}\|} \right\} \quad (36)$$

The signs of technical object structural damage are breakdown of characteristics (29).

Fig. 1, Fig. 2, Fig. 3 and Fig. 4 show phase biasing size graphs for different variants of structural damage.

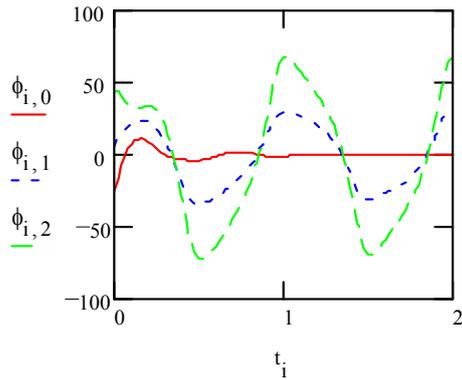


Fig. 1. Polynomials $B_i^{(2)}(z)$, $i=1,2,3$.

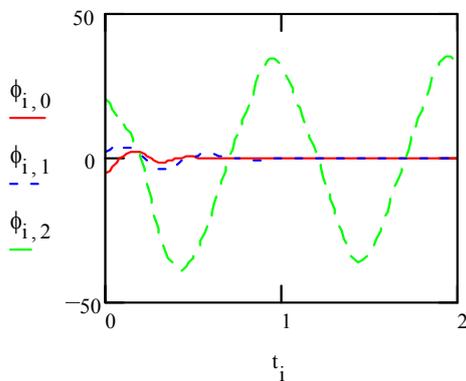


Fig. 2. Polynomials $B_i^{(4)}(z)$, $i=4,5,6$.

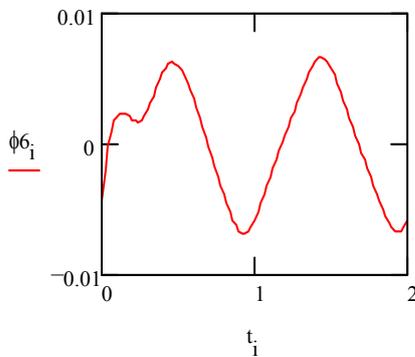


Fig. 3. Polynomials $B^{(7)}(z)$, $n=7$.

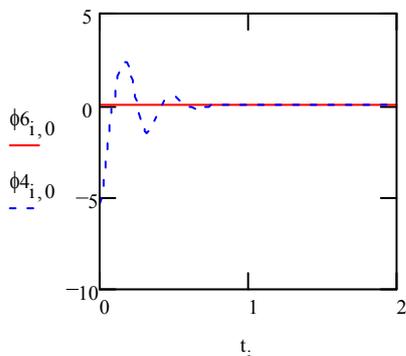


Fig. 4. Polynomials $B^{(n)}(z)$, $n=4, n=6$.

TABLE II
POLYNOMIAL $B^{(n)}(z)$, $N=4$ COEFFICIENTS

t_j	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2
$\beta_{4_{1,j}}$	2.2	32.5	12.8	9.6	8.5	8.3	9.2	9.2	9.1	9	9
$\beta_{4_{1,j}}$	-1.6	24.2	0.5	-2.4	-1.2	-0.9	-0.8	-0.9	-1	-1	-1
$\beta_{4_{1,j}}$	3.8	15.6	6.1	4.8	5	5	5.2	5.2	5.1	5.1	5.1
$\beta_{4_{1,j}}$	1	3.6	0.4	-0.1	0.3	0.4	0.4	0.3	0.3	0.3	0.3

TABLE III
POLYNOMIAL $B^{(n)}(z)$, $N=3$ COEFFICIENTS

t_j	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2
$\beta_{3_{1,j}}$	-2.1	44	-16.6	931.2	9-1.6	-5.5	-15.5	24.9	3.1	-1.4	
$\beta_{3_{2,j}}$	1.4	24.9	-0.6	-235.4	7.3	2.3	-0.7	11.6	5	3.6	
$\beta_{3_{3,j}}$	0.6	11.2	-2	-206.1	9.9	-0.1	-2.5	7.3	2	0.9	

Failure to comply with equation (29) requirements of the algorithm system solutions does not match their nominal values.

$$\beta_6^T := (11.023 \ -17.32 \ 17.021 \ -9.752 \ 5.777 \ -1.465)$$

The analysis shows that the image recognition geometrical parameters (in this case, the phase biasing values) can be used for optimization of the system. Therefore, for the creation of Y and Ω spaces, the Fourier transform systems with the following parameters can be used:

$$Fu(Bas_Y, \bar{y}) \in Y ; \tag{37}$$

$$Fu(Bas_\Omega, \bar{\xi}) \in \Omega . \tag{38}$$

The vector multiplication in (9) consists of linearly independent elements in the coordinate form:

$$Bas_Y = \{\varphi_{11}, \varphi_{12}, \dots, \varphi_{1n}\}$$

$$\bar{y} = c_{11}\varphi_{11} + c_{12}\varphi_{12} + \dots + c_{1n}\varphi_{1n} \tag{39}$$

$$Bas_\Omega = \{\varphi_{21}, \varphi_{22}, \dots, \varphi_{2n}\}$$

$$\bar{\xi} = c_{21}\varphi_{21} + c_{22}\varphi_{22} + \dots + c_{2n}\varphi_{2n} \tag{40}$$

The main task is to select the parameters of (37) and (38) for the model of image recognition, in order to implement the diagnostic pattern [2]

$$\Phi z(T) * \{x(t); y(t); U\}_U \Rightarrow \hat{W}_U(p) \quad (41)$$

In this case, systems (37) and (38) are replaced with multi-element approximations and subject to the Weierstrass theorem. In [4] recommendations are provided on how to correct Y and Ω recognition. Operators $Y * G \Rightarrow \Omega$ can be described by a linear operator and the calculation function can be described by the linear function:

$$d(x) = q_1 x_1 + q_2 x_2 + \dots + q_m x_m, \quad (42)$$

It follows from (6) that the spaces Y and Ω consist of vectors with real coefficients. For this reason, the recognition model exists in the Euclid space.

The systems (37) and (38) must be orthogonal (see 29). The operator G of image recognition must be used in problems regarding isometry [14]. In order to check these properties of (37) and (38), their geometrical parameters must be considered. They can be found by finding the Fourier coefficients for systems (39), (40). The algorithm uses the Gram matrices:

$$Gr_Y = (B_Y^T \cdot B_Y) \quad (43)$$

$$Gr_\Omega = (B_\Omega^T \cdot B_\Omega) \quad (44)$$

Components form the scalar product:

$$\left\{ \begin{aligned} [Gr]_{ij} &= [\overline{\varphi_{i1}} \overline{\varphi_{i2}} \dots \overline{\varphi_{in}}]^T \cdot \\ &\cdot [\overline{\varphi_{j1}} \overline{\varphi_{j2}} \dots \overline{\varphi_{jn}}] \end{aligned} \right\} \quad (45)$$

For space Y and Ω conversion elements, the vectors can be used:

$$\overline{C}_Y = Gr_Y^{-1} \cdot (B_Y^T \cdot \overline{y}) \quad (46)$$

$$\overline{C}_\Omega = Gr_\Omega^{-1} \cdot (B_\Omega^T \cdot \overline{\xi}) \quad (47)$$

Since the computerized diagnostic image recognition models of technical objects perform in Euclid space, the Gram matrix (43), (44) elements can be written as the geometric parameters of multiples. Let us denote by a matrix the vector system used in (45). The matrix (43) and (44) elements can be written as follows:

$$[G]_{ij} = [\overline{A}_i \cdot \overline{A}_j] \Rightarrow (l_i \cdot l_j) \cdot \cos \alpha_{ij} \quad l_{ij} \cdot C_{\xi_j} \quad (48)$$

In the Euclid space, systems (37) and (38) geometrical characteristics can be expressed by using the coordinates of vector modules and the phase shift angles to the cosine. Therefore, Gram matrix can be written as the product of

$$Gr = Dgl(l[\overline{A}]) \cdot Prmg(C_{\xi_j}) \cdot Dg2(l[\overline{A}]), \quad (49)$$

where the diagonal matrix consists of the coordinate vectors of the modules, but the average matrix gives cosine values of the angles. Angular rate can be measured by the projections of the vector system of system (43), (44) elements, for example, between different vector projections of Gram matrix subspaces. They provide the correlation of image recognition operator between the properties and mathematical evaluation. For example, the vector projection of the phase shifts of the coordinate space (39), (40):

$$\begin{aligned} \varphi_{\xi y} &= \text{arcCos} \left(\frac{\| (B_\xi \cdot Gr_\xi^{-1} \cdot B_\xi^T) \cdot \overline{\xi} \|}{\| \overline{\xi} \|} \right) - \\ &- \text{arcCos} \left(\frac{\| (B_y \cdot Gr_y^{-1} \cdot B_y^T) \cdot \overline{y} \|}{\| \overline{y} \|} \right) \end{aligned} \quad (50)$$

Isometric characteristics can be estimated by the projection vector compression coefficient:

$$KG = \left(\frac{\| (B_\xi \cdot Gr_\xi^{-1} \cdot B_\xi^T) \cdot \overline{\xi} \|}{\| (B_y \cdot Gr_y^{-1} \cdot B_y^T) \cdot \overline{y} \|} \right) \cdot \frac{\| \overline{y} \|}{\| \overline{\xi} \|} \quad (51)$$

Operator isometric properties of G can be measured by diagonal matrix (49) cell division and phase parameter (50) compliance. The projection vector compression ratios can be determined by the parameters of the root mean square deviation:

$$KG1 = \frac{\sqrt{\sum_{i=1}^N \|y_i - y_0\|}}{\sqrt{\sum_{i=1}^N \|w_i - w_0\|}} \quad (52)$$

$$KG2 = \frac{dy}{dw} \quad (53)$$

$$dw = \frac{\sqrt{\sum_{i=1}^N \|w_i - w_0\|}}{\|w_0\|}$$

$$dy = \frac{\sqrt{\sum_{i=1}^N \|y_i - y_0\|}}{\|y_0\|} \quad (54)$$

$$w_0 = \frac{1}{N} \sum_{i=1}^N w_i; y_0 = \frac{1}{N} \sum_{i=1}^N y_i$$

Example. Diagnosed three-level object with the following transformation function:

$$W(p) = \frac{p^2 + q_1 p + q_2}{p^3 + b_1 p^2 + b_2 p + b_2} \quad (55)$$

Properties of Y space result from the rationing vector of dynamic process:

$$y(t) = \frac{b_3}{q_3} \cdot \left\{ \left[\left(\frac{a_2 + a_1 \cdot s_1}{s_2} \right) \cdot \sin(s_2 \cdot t) + \right] \cdot \exp(s_1 t) \right\} + a_1 \cdot \cos(s_2 t) \quad (56)$$

Based on the previous information, matrix W_0 is presented as a matrix column vector $[q_1 \ q_2 \ b_1 \ b_2 \ b_3]$

$$W_0 := \begin{bmatrix} 8.664 & 9.161 & 9.47 & 9.256 & 9.586 & 9.455 \\ 17.654 & 14.027 & 10.964 & 7.935 & 6.853 & 5.434 \\ 15.695 & 13.598 & 9.196 & 8.808 & 9.641 & 8.515 \\ 36.876 & 31.556 & 19.105 & 18.36 & 19.958 & 16.482 \\ 71.777 & 43.569 & 19.215 & 14.839 & 13.345 & 8.894 \end{bmatrix} \quad (57)$$

It corresponds to the signal Y_0 matrix defined by formula (56) for time intervals (0 ... 1.0) sec with quantization period $T = 0.1$ sec. The Fourier models are formed as column matrix W_0 distribution options with the numbers corresponding to the matrix V :

$$V = \begin{bmatrix} 12 & 13 & 14 & 15 & 23 & 24 & 25 & 34 & 35 & 45 \\ 123 & 124 & 125 & 134 & 135 & 145 & 234 & 235 & 245 & 345 \\ 1234 & 1235 & 1245 & 2345 & 0 & 0 & 0 & 0 & 0 & 0 \\ 12345 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (58)$$

The combinations in the matrix Ω correspond to the combination of matrix Y

$$(W_{123}, W_{124}, \dots, W_{345}) * G = (Y_{123}, Y_{124}, \dots, Y_{345}) \quad (59)$$

Table IV gives the compression ratio for (52) and (53). The values are calculated for combinations of 2, of 3, 4 by the fifth. Table IV ranks the results arranged in order with increasing values of dw (54). Results are presented graphically by the scaling factor (2.5, 3.5, 4.5).

TABLE IV
THE COMPRESSION RATIO VALUES

(2,5)-dw	0.05	0.09	0.12	0.2	0.31	0.38	0.39	0.49	0.55	0.57
KG1	0.04	0.01	9.1210 ⁻³	9.7410 ⁻³	0.01	7.810 ⁻³	9.9210 ⁻³	0.01	8.7410 ⁻³	9.8810 ⁻³
KG2	0.65	0.27	0.17	0.48	0.35	0.22	0.28	0.42	0.33	0.37
(3,5)	0.11	0.37	0.38	0.4	0.41	0.45	0.46	0.59	0.6	0.64
KG	0.01	9.8310 ⁻³	0.01	0.01	9.1610 ⁻³	8.7310 ⁻³	9.8710 ⁻³	9.7810 ⁻³	0.01	9.3910 ⁻³
KG2	0.27	0.25	0.27	0.42	0.22	0.33	0.38	0.3	0.32	0.28
(4,5)-dw	0.38	0.49	0.5	0.53	0.62	0	0	0	0	0
KG1	9.9810 ⁻³	9.7710 ⁻³	0.01	9.3310 ⁻³	9.8510 ⁻³	0	0	0	0	0
KG2	0.23	0.33	0.34	0.3	0.27	0	0	0	0	0

Fig. 5-7 show the compression ratio (52) and (53) in the various bases.

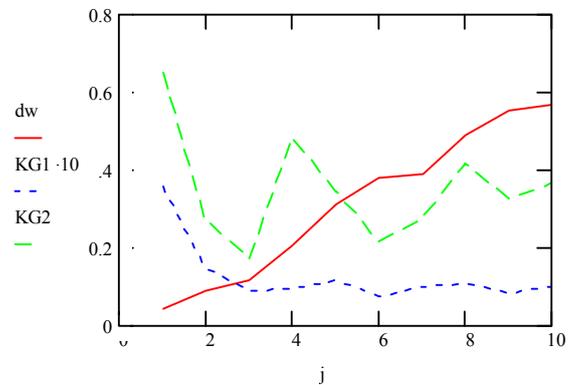


Fig. 5. The compression ratio changes to second-degree base.

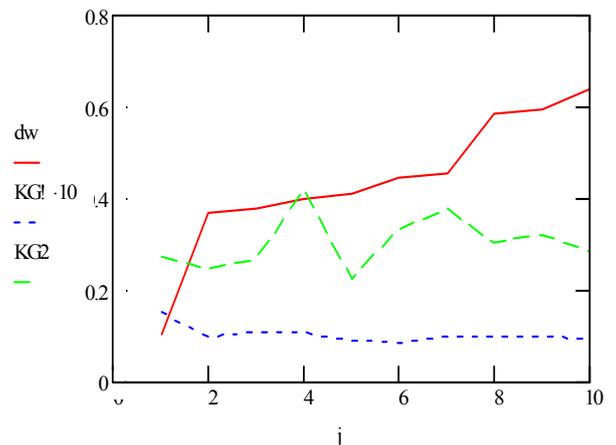


Fig. 6. The compression ratio changes to fourth-degree base.

In Fig. 7, the graphs illustrating the compression ratio changes depend on the degree of base.

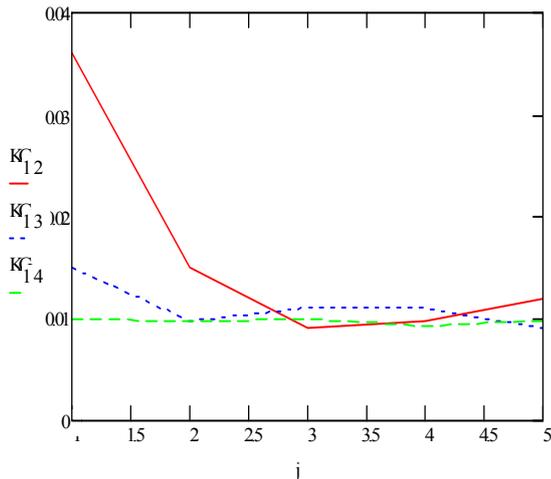


Fig. 7. The compression ratio.

Space Ω elements are taken from matrix W_{new} elements (60).

$$W_{\text{new}} = \begin{bmatrix} 9.42 & 9.5 & 9.58 & 9.66 & 9.74 & 9.82 & 9.9 & 9.99 & 10.07 & 10.16 & 10.2 \\ 6.01 & 6.1 & 6.2 & 6.3 & 6.4 & 6.51 & 6.62 & 6.73 & 6.84 & 6.96 & 7.08 \\ 8.28 & 8.33 & 8.38 & 8.43 & 8.49 & 8.55 & 8.6 & 8.66 & 8.72 & 8.79 & 8.85 \\ 15.65 & 15.72 & 15.79 & 15.87 & 15.95 & 16.03 & 16.12 & 16.21 & 16.3 & 16.39 & 16.4 \\ 9.12 & 9.16 & 9.2 & 9.24 & 9.28 & 9.32 & 9.37 & 9.41 & 9.46 & 9.51 & 9.56 \end{bmatrix} \quad (60)$$

Matrix Y_{new} form was used a fixed base from (56). Matrix A consisted of three matrices W_0 column vectors. The vector angular deviation was determined by (61):

$$\begin{aligned} Ka &= ay_i / aw_i; \\ aw_i &= \arccos(\bar{y}_i; A_{W_0}); \\ ay_i &= \arccos(\bar{y}_i; A_{Y_0}) \end{aligned} \quad (61)$$

Table V summarizes the phase deviations and the detection of possible errors $h(\%)$ in the model, using the linear function. New column vectors of appropriate matrices Y_0 and Y are given by (56) in time intervals (0 ... 1.0) sec with quantization period $T = 0.1$ sec.

TABLE V
DIAGNOSTIC ERROR H (%)

	0	1	2	3	4	5	6	7	8	9	10	11
aw	6.794	6.714	6.632	6.548	6.462	6.375	6.285	6.193	6.1	6.004	5.907	
ay	0.696	0.733	0.77	0.808	0.845	0.883	0.92	0.958	0.995	1.032	1.069	
Ka	0.102	0.109	0.116	0.123	0.131	0.139	0.146	0.155	0.163	0.172	0.181	
h	27.24	18.05	11.41	12.12	19.17	27.992	37.235	46.557	55.841	65.035	74.114	

IV. CONCLUSIONS

Diagnostic models must include image recognition models that allow incorrect mathematical operations to provide the right solutions.

Image recognition models can be used for optimization process of geometrical parameters with the Gramian inverse matrix operations.

Implementation of the image recognition system for Fourier models depends on the form of the basic information, which is not always sufficient, does not enable escape from many mistakes and it is desirable to change the Gaussian algorithm by the algorithm based on the composite mathematical model.

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