ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 3 , March 2017

Regular Correction Algorithms for Dynamic Errors of Measuring

Igamberdiyev H.Z., Shipulin Yu.G., Mahmudov M.I.

Department of Intellectual engineering systems, Tashkent State Technical University, Tashkent, Uzbekistan

ABSTRACT*:* The problems of the formation and building of stable dynamic error correction algorithms for measuring instruments in the framework of the general problem of uncontrolled recovery signals in measuring and converting units. We give stable algorithms of correction of dynamic errors based on the method of regularization and regular procedures within the framework of the principle of iterative regularization. The proposed algorithm can improve the computational stability of algorithms of correction of dynamic error of measuring instruments and can be used in information processing and measuring the results of observations systems.

KEYWORDS: information - measuring system, measuring instrument, the dynamic correction of errors, regular algorithms.

I. INTRODUCTION

Signal restoration problem is related to the general problem of distortion and correction of measuring and converting devices [1-3]. Usually by controlling, recording, measuring and converting devices are requirements of the minimal dynamic distortion of the measured value. In doing so, it complies with the requirements of the quantities of recoverable and measurement recording device. The general condition of the minimum dynamic distortions is performed when the input and output of the measuring system linked algebraic dependence. It follows that if the equation describing the dynamics of controlling, measuring and converting device is a differential, in general, distortion is inevitable. This is due to the fact that non-homogeneous differential equation is a function that is different from the right side of the original equation.
The construction of these systems provides the most complete information about the operation of automatic control system as a whole, as well as relevant information about the control actions, disturbances and coordinates belonging to the class of unmeasured and uncontrolled signals measuring equipment [3,4].
The task of restoring the initial state of the input and influence on the results of the dynamic system output measurement belongs to a class of inverse problems of the dynamics of control systems [5,6]. Since this problem is ill-posed, for its solution methods should be used, developed in the corresponding theory [7-12].
The paper deals with the formation and construction of means of measurements of the dynamic error correction algorithms sustained through regular methods.

II. TEXT DETECTION

Consider the linear measuring system described by the equations

$$x_{k+1} = A_k x_k + B_k w_k,\ \ x(k_0) = x^0, \tag{1}$$

$$y_k = C_k x_k + D_k w_k, \tag{2}$$

where $x \in R^n, w \in R^p, y \in R^m$; $x = x_k$ - the state of the system; x^0 - the initial state of the system; $w_k \in L_2^p$ - input immeasurable impact on the system; $y_k \in L_2^m$ - output of the system; A_k, B_k, C_k, D_k - the matrix of appropriate dimensions.
Let

$$\Theta = R^n \times L_2^p,\ Y = L_2^m.$$

In the space of Θ, we define a scalar product of the form

$$\langle \theta_1, \theta_2 \rangle_\Theta = \langle x_1^0, x_2^0 \rangle_{R^n} + \langle w_1, w_2 \rangle_{L_2^p},$$

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 3 , March 2017

which turns into a Hilbert space Θ.
Equations (1), (2) define a linear operator $F:\Theta\to Y$ [13], which each pair $\theta=(x_0,w)\in\Theta$, ie, entry system assigns the function $y\in Y$ at the output of the system. Thus we arrive at the operator equation of the form

$$F\theta=y,\ \ \theta\in\Theta,\ \ y\in Y. \tag{3}$$

We pose the problem of the approximate reconstruction of the element $\theta=(x_*^0,w)$ from the measurements of the output y of the measuring system.
In practical applications the right part y and F elements of the matrix, i.e. coefficients of the system (3) are known only approximately. In these cases, instead of (3) used other system

$$F_h\theta=y_\delta, \tag{4}$$

such that $\|F_h-F\|\le h,\ \ \|y_\delta-y\|\le\delta$. Thus, characterized approximate data set $F_h,\ y_\delta,\ \eta$ where $\eta=\{\delta,h\}$ - vector error.
When solving equation (4), as a rule, violated the conditions of the stability of solutions related to poor conditioning of the matrix F_h. These circumstances lead to the need for regularization methods.

III.SOLUTION OF THE TASK

We write the expression for smoothing functional A.N. Tikhonov

$$M^\alpha[\theta_\eta^\alpha]=\left\|F_h\theta_\eta^\alpha-y_\delta\right\|_{Y^2}+\alpha\left\|\theta_\eta^\alpha\right\|_{\Theta^2},$$

where $\alpha>0$ - the regularization parameter.
Consider the following functions [7]:

$$\gamma_\eta(\alpha)=\left\|\theta_\eta^\alpha\right\|_{\Theta^2},$$

$$\beta_\eta(\alpha)=\left\|F_h\theta_\eta^\alpha-y_\delta\right\|_{Y^2},$$

$$\rho_\eta(\alpha)=\beta_\eta(\alpha)-\left(\delta+h\sqrt{\gamma_\eta(\alpha)}\right)^2-\mu_\eta^2.$$

Here θ_η^α - extremal functional A.N. Tikhonov $M^\alpha[\theta]$ at a fixed monotonic $\alpha>0$. Functions $\gamma_\eta(\alpha)$, $\beta_\eta(\alpha)$, $\rho_\eta(\alpha)$ and α are continuous as functions in the field of $\alpha>0$, $\mu_\eta=\inf\limits_{\theta\in D}\left\|F_h\theta-y_\delta\right\|_Y$ - the incompatibility of the measure μ_η of the equation (4) with approximate data on a set of $D\in\Theta$.
The solution of equation (4) based on the regularization method of A.N. Tikhonov is given by [7.11]

$$\theta_\alpha=(\alpha I+F_h^TF_h)^{-1}F_h^Ty_\delta=g_\alpha(F_h^TF_h)F_h^Ty_\delta,$$

where $g_\alpha(\lambda)=(\alpha+\lambda)^{-1},\ \alpha>0,\ \ 0\le\lambda<\infty$ - generating system functions for method of A.N. Tikhonov.
We assume that the following natural condition

$$\left\|y_\delta\right\|^2>\delta^2+\mu_\eta^2. \tag{5}$$

$\rho_\eta(\alpha)$ generalized residual function has the following limit values at the ends of [8]

$$\lim_{\alpha\to+\infty}\rho_\eta(\alpha)=\left\|y_\delta\right\|_U^2-\delta^2-\mu_\eta^2,$$

$$\overline{\lim_{\alpha\to0+0}}\,\rho_\eta(\alpha)=-\delta^2.$$

Thus, when the condition (5) in equation $\rho_\eta(\alpha)=0$ has a region $\alpha>0$ of the root $\alpha^*(\eta)$, the element $\theta_\eta^{\alpha^*(\eta)}$ is determined uniquely.
If the numbers h and δ are unknown or their computation involves considerable difficulties, the regularization parameter α can usefully be measured based on the method quasioptimality [7,10]

$$\left\|\theta^{(\alpha_{i+1})}-\theta^{(\alpha_i)}\right\|=\min,\quad \alpha_{i+1}=\varsigma\alpha_i,\quad i=0,1,2,..,\quad 0<\varsigma<1.$$

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 3 , March 2017

In the absence of a priori information about the level of error in the initial data of the equation (4) is also very effective numerical schemes are choosing the regularization parameter using rapidly converging iterative methods for solving the type of tangent method Newton's equations [9].

When constructing an approximate solution of the equation (4) in the case of a reversible operator F_h also play a big role various iterative methods [11,12]. These techniques can be either linear or when to go to the next iterative approximation is required to apply a linear operator to one or more previous approximations and non-linear, non-linear when the transition operator. It is known [12] that the commonly used methods of linear iterative approximations may generate in the case of irreversible operator F_h. Equipped with suitable stop rule $r(\delta,h)$, the iterative process, in turn, generate algorithms for regularizing (4) of the problem.

From this point of view is more convenient variant of the iterated regularization A.N. Tikhonov [11]:

$$\alpha\theta_{r,\alpha} + F_h^T F_h\,\theta_{r,\alpha} = \alpha\theta_{r-1,\alpha} + F_h^T y_\delta \quad (r = 1,\dots,m). \tag{6}$$

The solution of equation (6) is given - by the formula

$$\theta_{m,\alpha} = (I - F_h^T F_h\, g_{m,\alpha}(F_h^T F_h))\theta_0 + g_{m,\alpha}(F_h^T F_h)F_h^T y_\delta, \tag{7}$$

where θ_0 - the initial approximation, and $g_{m,\alpha}(\lambda)$ - generating system functions for an iterated version (6) of the method A. Tikhonov is given by

$$g_{m,\alpha}(\lambda) = \frac{1}{\lambda}\left[1 - \left(\frac{\alpha}{\alpha+\lambda}\right)^m\right], \qquad 0 \le \lambda < \infty.$$

Parameter $r = r(\delta,h)$ in the approximation (7) should be chosen so that [11]

$$r(\delta,h) \to \infty, \quad (\delta+h)^2 r(\delta,h) \to 0, \text{ at } \delta \to 0, \quad h \to 0.$$

Then $\theta_{r(\delta,h)} \to \theta_*$ at $\delta \to 0,\ h \to 0$ where θ_* - a solution of $F_h^T F_h \theta_* = F_h^T y$.

It is advisable to use the following rule stop the iterative process:

Specifies the number of $b_1 > 1$ and $b_2 \ge b_1$. If $\|F_h\theta_0 - y_\delta\| \le b_2(\delta + \|\theta_0\|h)$ then set for $r = 0$ and the approximate solution we take u_0. Otherwise choose a $r > 0$, in which $b_1(\delta + \|\theta_r\|h) \le \|F_h\theta_r - y_\delta\| \le b_2(\delta + \|\theta_r\|h)$. If the $r \in [0, d/(\delta+h)^2]$ discrepancy has not reached the level of $\|F_h\theta_r - y_\delta\| \le b_2(\delta + \|\theta_r\|h)$, the search stops r and $r = d/(\delta+h)^2$ selected.

To calculate the required vector θ may also be used, such as other kinds of iterative scheme [10]

$$\varepsilon\theta_r + F_h^T F_h\theta_r = \varepsilon\theta_{r-1} + F_h^T y^\delta, \quad \varepsilon > 0, \quad r = 1,2,\dots,$$

$$(\alpha I + F_h^T F_h)\theta_r = \alpha\theta_{r-1} + F_h^T y^\delta, \quad r = 1,2,\dots,$$

which are adjacent to the regular iterative algorithms.

It can be shown [14] that for the considered problem is a highly effective non-linear iterative algorithm of the form:

$$\theta_{r+1} = \theta_r - (\varepsilon_r I + F_h^T F_h)^{-1} F_h^T (F_h\theta_r - f_\delta), \quad \theta_0 = 0,$$

$$\varepsilon_r = \begin{cases} \bar{\varepsilon}_r = \dfrac{\left\|F_h^T(F_h\theta_r - f_\delta)\right\|^2}{\left\|F_h\theta_r - f_\delta\right\|^2}, & \bar{\varepsilon}_r \ge \psi(\delta,h) > 0, \\ \psi(\delta,h), & \bar{\varepsilon}_r < \psi(\delta,h), \end{cases} \tag{8}$$

where $\Psi(\delta,h)$ - the predetermined threshold function such that

$$\lim_{\delta\to 0, h\to 0} \Psi(\delta,h) = 0, \quad \Psi(0) = 0.$$

Then, following the theory of iterative methods [11,12,14], we can show that if

$$\lim_{\substack{\delta\to 0, h\to 0\\ r\to\infty}} (\delta + h\|\hat{\theta}_\xi\|)\sum_{j=0}^{k}(\varepsilon_j)^{-1/2} = 0,$$

then

$$\lim_{\substack{\delta\to 0,\, h\to 0 \\ r\to\infty}} \left\| \theta_{r+1} - \hat{\theta}_r \right\| = 0, \qquad \hat{\theta} \perp \ker F_h^T F_h \, .$$

The iterative process (8), remaining nonlinear in the first iteration, converges faster than the number of known iterative algorithms.

IV. CONCLUSION

These algorithms are used to obtain the most complete information about the operation of automatic control of various technological objects as a whole, as well as relevant information about the control actions, disturbances and coordinates belonging to the class of unmeasured and uncontrolled measuring signal equipment and can be used in information-measuring results processing systems observations of the state of a dynamic system.

REFERENCES

[1] Granovsky V.A. Dynamic measurements: Fundamentals of metrology software. - L.: Energoatomisdat, Leningrad. branch, 1984. -224 p.
[2] Vasilenko G.I. Theory signals recovery: On the reduction to an ideal instrument in physics and engineering. -M.: Soviet Radio, 1979. - 272 p.
[3] Kuznetsov B.F. Stochastic models and methods of analysis of information - measuring systems ACS /Angarsk: Angarsk State Technical Academy, 2007. - 180 p.
[4] Drozdov I.V., Miroshnikov I.V., Skorubsky I.V. Automatic control systems with microcomputers. -A.: Mechanical engineering. Leningrad. Office, 1989. - 284 p.
[5] Petrov B.N., Krut'ko P.D. Inverse problems of the dynamics of control systems. Linear models // Bulletin of the Academy of Sciences, Technical Cybernetics, 1980, №4. - S.147-156.
[6] Galiullin A.S. Methods for solving inverse problems of dynamics. -M.: Nauka, 1986.
[7] Tikhonov A.N., Arsenin V.Y. Methods for solving ill-posed problems. -M.: Nauka, 1979. - 285 p.
[8] Invalid task of natural science / Edited by A.N. Tikhonov A.V. Goncharsky. - M.: Izd. University Press, 1987. -299 p.
[9] Morozov V.A. Regular methods for solving ill-posed problems, M.: Nauka, 1987.
[10] Verlan A.F., Sizikov V.S. Integral equations: methods, algorithms and programs. Naukova Dumka, 1986. - 542 p.
[11] Vainikko G.M., Veretennikov A.J. Iterative procedure in ill-posed problems. -M.: Nauka, 1986 - 178 p.
[12] Bakushinskii A.B., Goncharsky A.V. Iterative methods for solving ill-posed problems. -M.: Nauka, 1989. -128 c.
[13] Anikin S.A. An error estimate for the method of regularization in the problem of reconstructing the input dynamic systems //J. Mat. and Math. Phys., 1997, Volume 37, №9. - S.1056-1067.
[14] Trushnikov V.N. One non-linear regularizing algorithm and some of its applications, J. Mat. and Math. Phys., 1979, Volume 19, Number 4, -C. 822-829.

AUTHOR'S BIOGRAPHY

Igamberdiyev Husan Zakirovich - Doctor of technical sciences, Professor of Department of “Intellectual engineering systems”, Tashkent State Technical University named after I.A. Karimov. Author of 8 monograph, more than 12 textbooks, 15 patents and more than 502 articles in scientific and technical journals and publications.

Shipulin Yuriy Gennadiyevich – Doctor of technical sciences, Professor of Department of “Intellectual engineering systems”, Tashkent State Technical University named after I.A. Karimov. Author of 6 monograph, more than 12 textbooks, 20 patents and more than 301 articles in scientific and technical journals and publications.

Makhmudov Makhsud Idrisovich – Ph.D., Associate Professor and Head of the Department “Electrical Equipment” Bukhara Engineering Technology Institute. Author of 2 monograph, more than 6 textbooks, 8 patents and more than 91 articles in scientific and technical journals and publications.