ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 8 , August 2016

Algorithms of the adaptive estimation in the conditions of uncertainty of the perturbing influences

Mamirov U.F., Zaripov O.O.

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

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

ABSTRACT: Questions of formation and creation the regularization algorithms of the adaptive estimation on the basis of filters of Kalman type in the conditions of uncertainty of the perturbing influences are considered. The concept of the adaptive algorithm consists in setup of a matrix of gain amounts so that correlation in residual members decreased. The expressions for an assessment of an error of the right part of the matrix equation for computation of gain amount allowing are received without making the direct solution of the matrix equation to evaluate an error of its decision. In case of the solution of the considered optimization task the regularization option of a method of a projection of a gradient and a method of moderate damage of M.M. Lavrentyev's were used.

KEYWORDS: adaptive estimation, filter of Kalman, gain amount perturbing influence, uncertainty, regularization.

I. Introduction

Traditional methods of the analysis and synthesis of management systems are based on the assumption that the mathematical model of object is known and absolutely precisely describes his behavior [1,2]. However more critical view of the accuracy of mathematical models, available the developer is characteristic of the modern approaches to setting and the solution of tasks of control. The matter is that practically any model represents idealized, i.e. simplified, the description of real object. Besides, some characteristics of object can be in advance unknown or change considerably in the course of its functioning. At the same time speak about model uncertainty or simply – about indefinite object, understanding as it uncertainty of its mathematical model. In these cases application of ad hoc methods of the analysis and synthesis of the adaptive systems of object management with indefinite mathematical models is necessary [3-8].

Difficulties of creation of algorithms and management systems are, as a rule, connected by dynamic objects to complexity of their mathematical models: nonlinearity, stochasticity, high order of differential equations, etc. Different uncertainties belong to number of the most essential factors which need to be considered in case of creation of laws of control of different dynamic systems.

Uncertainty is that some characteristics of a control object can be in advance unknown or change considerably (including in an unpredictable way) in the course of its functioning. In these conditions classical methods of the theory of control, as a rule, are inapplicable or yield unsatisfactory results. Unforeseen changes of properties of the functioning object can significantly worsen quality of controlled processes and even to lead to its nonserviceability.

On behavior of real management systems the considerable impact is exerted by environment, i.e. uncontrollable external factors which are characterized by a high level of uncertainty. For its overcoming use different methods of identification or adaptive compensating of the perturbing influences [4,9].

Now there are several tens approaches which are specially developed for research of technical systems with uncertainty elements. The mains from them are the adaptive [4,6], robust [4], intellectual (on the basis of neurosimilar networks and "soft" computation) [7,10], the invariant [2,8] principles of creation of systems of automatic control.

The adaptive or self-organized systems are intended for functioning in the conditions of removable uncertainties. Those parameters and characteristics of management system which are a priori unknown belong to such type of uncertainties, but can be evaluated or calculated in the course of real system operation according to the operational data arriving from measuring systems.

Irrespective of assignment of the adaptive system and the accepted approach to creation by the general in all cases the job of the main circuit of the control including object and the regulator is. Depending on character and the volume of

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 8 , August 2016

prior information on object and external impacts on it, levels of influence of incompleteness of information on quality of control can be spoken, first, about the adaptation caused by incompleteness prior and existence of the current uncertainty of knowledge of external influences; secondly, about the adaptation caused by incomplete prior and current information on parameters of the equations describing objects; thirdly, about the adaptation caused by changes of both parameters, and influences. In the first case speak about signal adaptation, in the second - about parametric [6,8].

So far in the theory of the adaptive systems methods of parametric adaptation gained the considerable development [1,2,5,6]. However the methods of signal adaptation caused by incompleteness prior and existence of the current uncertainty of knowledge of external influences didn't gain due development, in particular, it is questions of estimation of indefinite perturbations in dynamic management systems and uncontrollable input influences on the basis of the watching devices of influences. In this regard there is a need of development and development of algorithms of the adaptive estimation on the basis of the filter of Kalman in the conditions of uncertainty of the perturbing influences.

II. PROBLEM DEFINITION

We will consider the linear dynamic system described by the equations

$$x_{i+1} = Ax_i + \Gamma w_i, \tag{1}$$

$$z_i = Hx_i + v_i, \tag{2}$$

where x_i – state vector of system of dimensionality of n, z_i – a vector of observation of dimensionality of m, w_i and v_i – the vectors of noise of object and a noise of observation of dimensionality of q and p respectively which are sequence like a gaussian white noise with characteristics $E[w_i]=0$, $E[w_i w_k^T]=Q\delta_{ik}$, $E[v_i]=0$, $E[v_i v_k^T]=R\delta_{ik}$, $E[w_i v_k^T]=0$; A, Γ and H – matrixes of the appropriate dimensionalities.

The equations describing optimum algorithm of estimation of Kalman have an appearance [1,11]:

$$\hat{x}_{i|i-1} = A\hat{x}_{i-1|i-1}, \tag{3}$$

$$\hat{x}_{i|i} = \hat{x}_{i|i-1} + K_i y_i, \tag{4}$$

$$K_i = P_{i|i-1}H^T[HP_{i|i-1}H^T + R_i]^{-1}, \tag{5}$$

$$P_{i|i-1} \overset{\Delta}{=} E\left\{[x_i - \hat{x}_{i|i-1}][x_i - \hat{x}_{i|i-1}]^T\right\} = AP_{i-1|i-1}A^T + \Gamma Q_{i-1}\Gamma^T, \tag{6}$$

$$P_{i|i} \overset{\Delta}{=} E\left\{[x_i - \hat{x}_{i|i}][x_i - \hat{x}_{i|i}]^T\right\} = (I - K_iH)P_{i|i-1}(I - K_iH)^T + K_iR_iK_i^T, \ \hat{x}_{0|0} = \hat{x}_0, \ P_{0|0} = P_0. \tag{7}$$

Important property of the optimum filter is in volume [11,12] that the residual members defined as

$$y_i = z_i - H\hat{x}_{i|i-1}, \tag{8}$$

are sequence of a type of a white noise. At the same time covariance of the residual member is equal

$$\mathrm{R}_0 \overset{\Delta}{=} E[y_i y_i^T] = HP_{i|i-1}H^T + R_i, \tag{9}$$

and the autocovariance matrix of process y_i is equal

$$\mathrm{R}_j \overset{\Delta}{=} E[y_{i+j} y_i^T] = H[A(I - K_iH)]^{j-1}A[P_{i|i-1}H^T - K_i\mathrm{R}_0], \tag{10}$$

in case of $j = 1,2,3,\ldots$, where K – arbitrary gain amount.

We will assume that covariances of noise Q_i and R_i are unknown. It is clear, that in this case the matrix of optimum gain amounts can't be defined. If, however, the gain amount can be selected by it that

$$P_{i|i-1}H^T - K_i\mathrm{R}_{0,i} = 0, \tag{11}$$

that in case of an assumption that the matrix $\mathrm{R}_{0,i}$ is reversible, gain amount K_i is optimum. And back, if gain amount optimum, then the equation (11) is fair.

The last two statements are set that the coefficient K_i is optimum in only case when, when the equation (11) is fair. If residual members are correlated, then the matrix of gain amounts is set up so that the right member of equation (11) had smaller norm, than earlier. Processes of measurement of correlation and setup of gain amount continue until the equation (11) doesn't become fair, i.e. correlation of residual members won't be removed completely yet.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 8 , August 2016

III.SOLUTION OF THE TASK

In the equations (4) – (10) it is supposed that gain amount K has some arbitrary (nonoptimal) value which provides stability of the equations of the filter (3) and (4). Adding the equation (3) in (4), we receive

$$\hat{x}_{i|i} = (I - K_i H) A \hat{x}_{i-1|i-1} + K_i z_i \,. \tag{12}$$

Defining S matrix as

$$S = PH^T - K\mathrm{R}_0, \tag{13}$$

the equation (5) can be written in a look:

$$\mathrm{R}_j = H[A(I - KH)]^{j-1} AS \,. \tag{14}$$

Absolute minimum of a functionality of J, difiniendum in a look

$$J = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{m} s_{ij}^2 \,, \tag{15}$$

it is reached in case of $S = 0$, where s_{ij} – the (i, j)-th array element S.

For determination of gain amount K which leads a matrix S to zero we will use a method of a projection of a gradient [13,14]. The choice of this method is caused by the fact that the method of a projection of a gradient is very effective in the conditions of the approximate job of basic data, provides the acceptable accuracy of the solution of auxiliary tasks and extension of sets that the received sequences were minimizing and the regular in the required metrics.

We will write a method of a projection of a gradient in a look:

$$k_{i+1}^r = P_{\mathrm{K}}(k_i^r - \beta_i J'(k_i^r)), \; i = 0,1,..., \; r = 0,1,2,3,..., \tag{16}$$

where $P_{\mathrm{K}}(k)$ – a projection of a point k on a set K, $\beta_i > 0$; K – convex closed set.

For minimization of a functionality (15) according to (16) it is necessary to calculate the equations:

$$\frac{\partial f}{\partial k_{\mu\lambda}} = \sum_{i=1}^{n}\sum_{j=1}^{m} s_{ij}^2 \frac{\partial s_{ij}}{\partial k_{\mu\lambda}} \,, \tag{17}$$

$$\frac{\partial S}{\partial k_{\mu\lambda}} = (I - KH)\frac{\partial P}{\partial k_{\mu\lambda}} H^T - \frac{\partial K}{\partial k_{\mu\lambda}} \mathrm{R}_0 \,, \tag{18}$$

$$\frac{\partial P}{\partial k_{\mu\lambda}} = [A[(I - KH)]\frac{\partial P}{\partial k_{\mu\lambda}}[A(I - KH)]^T - A\left[\frac{\partial K}{\partial k_{\mu\lambda}} S^T + S\frac{\partial K^T}{\partial k_{\mu\lambda}}\right] A^T \,, \tag{19}$$

where $k_{\mu\lambda}$ – is the (μ, λ) -th array element K.

In case of the solution of these equations it is possible to use the famous numerical methods [14,15,16] widely.

For determination of values R_0 we will use the following not displaced well-grounded assessment of parameter R_0 based on N sequential residual members:

$$\hat{\mathrm{R}}_0 = \frac{1}{N-1}\sum_{i=1}^{N} y_i y_i^T \,. \tag{20}$$

The assessment of parameter S can be received the solution of the equation (14) for several values j with use of selective statistics as not displaced well-grounded estimates R_j. The assessment S is defined on the basis of expression

$$D \cdot \hat{S} = \hat{\mathrm{R}} \,, \tag{21}$$

where

$$D = \begin{bmatrix} HA \\ \hdashline H[A(I-KH)]A \\ \hdashline \vdots \\ \hdashline H[A(I-KH)]^{j_{\max}-1} A \end{bmatrix}, \quad \hat{\mathrm{R}} = \begin{bmatrix} \hat{\mathrm{R}}_1 \\ \hdashline \hat{\mathrm{R}}_2 \\ \hdashline \vdots \\ \hdashline \hat{\mathrm{R}}_{j_{\max}} \end{bmatrix},$$

$$\hat{\mathrm{R}}_j = \frac{1}{N-j}\sum_{i=1}^{N-j} y_{i+j} y_i^T, \; j = 1,2,..., j_{\max}, \; j_{\max} = \eta \,, \tag{22}$$

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 8 , August 2016

and value $j_{\max}$ can be selected so that the matrix which is subject to the address had the sizes $n \times n$ and a rank n.
After receiving estimates of parameters R_0 and S, they can be added in the equations (16) – (19) to receive an assessment of value $\partial f / \partial k_{\mu\lambda}$ for use in the equation (16).
In the given setting classical algorithms of type (16) can provide only feeble convergence of sequence of approaches $k^r_{\mu\lambda}$. It is caused by the fact that direct use of the equation (16) for searching of estimates of elements $k_{\mu\lambda}$ of optimum gain amount K can lead to the fact that in case of as much as small error in the job of basic data the lower edge of a functionality on the perturbed set can differ considerably from the lower edge of this functionality on the given set initial precisely. In other words, errors in the job of the initial sets can result in instability of the considered task of minimization.
For the solution of the considered task we will use methods of regularization [13,17]. We will make more detail formalization of the considered task of minimization for the purpose of formation of regularizations algorithm on the basis of methods and concepts of the solution of incorrect tasks.
We will designate through the $\mathrm{K} = \{k : k \in \mathrm{K}_0\}$ set of decisions on which the minimum of a functionality $J(k)$ where K_0 – convex closed set from Hilbert space H is looked for. We will assume that $\mathrm{K} \neq \varnothing,\ J_* = \inf_{k \in \mathrm{K}} J(k) > -\infty$, $\mathrm{K}_* = \{k : k \in \mathrm{K},\ J(k) = J_*\} \neq \varnothing$.
We will assume also that an error in the job of a gradient of function $J(k)$ such is that

$$\|J'(k)\| \le L_0(1 + \|k\|),\ k \in \mathrm{K},\ L_0 = const \ge 0,$$

$$\max \left\| J'(k) - J_i'(k) \right\| \le \delta_i (1 + \|k\|),\ k \in \mathrm{K}_0, \qquad (23)$$

where $\delta_i \ge 0,\ i = 1,2,...,\ \lim_{i \to \infty} \delta_i = 0$.
We will enter A.N. Tikhonov's function

$$T_i(k) = J_k(k) + \alpha_k \Omega(k),\ k \in \mathrm{K}_0, \qquad (24)$$

where $\alpha_i > 0,\ i = 1,2,...,\ \lim_{i \to \infty} \alpha_i = 0$, and the stabilizator serves function $\Omega(k) = \|k\|^2 / 2$. In case of the made assumptions function (24) is differentiated, and its gradient has an appearance $T_i'(k) = J_i'(k) + \alpha_i k_i,\quad k \in \mathrm{K}_0$.
Then, following [13,18], it is possible to show that the sequence determined by a condition

$$v_{i+1} = P_{\mathrm{K}_0}(v_i - \beta_i (J_i'(v_i) + \alpha_i v_i)),\quad i = 1,2,...;\ v_1 \in \mathrm{K}, \qquad (25)$$

meets on norm H to a point $k_* \in \mathrm{K}_*$ with the minimum norm, i.e. $\lim_{i \to \infty} \|k_i - k_*\| = 0$, at the same time $\lim_{i \to \infty} \|v_i - k_i\| = 0$, $\beta_i > 0, i = 1,2,...,\ \lim_{i \to 0} \beta_i = 0$.
The sequences $\{\alpha_i\}, \{\beta_i\}$, meeting a condition (25) can be picked up, for example, in the form of $\alpha_i = i^{-1/\alpha}, \beta_i = i^{-1/\beta}$ where $\alpha,\ \beta$ – the natural numbers satisfying to system of inequalities $\alpha^{-1} + \beta^{-1} < 1,\ \beta < \alpha$. In particular, it is possible to take $\alpha_i = i^{-1/3},\ \beta_i = i^{-1/2},\ i = 1,2,...$. Also the limit ratio of a look $\lim_{i \to \infty} \delta_i \alpha_i^{-1} = 0$ shall be executed. The condition $\lim_{i \to \infty} \delta_i \alpha_i^{-1} = 0$ superimposes the requirement of an error of the job of a gradient according to a condition (23).
The system of equations (21) for determination of an assessment of S can be badly caused, i.e. big changes of the decision can respond small changes of basic data. We will make characterization of the considered system of equations for regularization of the solution of the equation (21).
The right part of system (21) is result of processing of the experimental data and represents the column vector of block type. Each unit consists of matrixes $\hat{\mathrm{R}}_j$, which elements are correlation coefficients and y_i volumes $N - j$ are calculated by means of selective and step algorithm on the basis of expression (22) on implementations of residual members. Residual members in turn are calculated on the basis of a ratio (8) in the conditions of noises by results of physical measurements and for this reason are known only approximately.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 8 , August 2016

Thus, for establishment of accuracy of computation of a matrix S in the conditions of a bad conditionality of the matrix operator D and the approximate job of the right part $\hat{\mathrm{R}}$ of system (21) it is necessary to evaluate an error of its job. Information obtained thus can be used for a choice of optimum parameter of regularization.

We will make the assumption that errors of correlation coefficients are subordinate to the normal distribution law. Such assumption is fair that each assessment of correlation coefficient $\hat{r}$ represents the random, normal distributed variable with certain mean value $E\{\hat{r}\}$ and with a mean squared deviation σ_r. Normality of distribution of an assessment follows from what $\hat{r}$ turns out summing of work of rather bigger number of accidental values y_i in different timepoints [19].

Then for confidential probability $P = 0{,}95$ it is possible to write the following limit values of elements of the right member of equation (21):

$$\tilde{\mathrm{R}} = \begin{bmatrix} \tilde{\mathrm{R}}_{1(i)} \\ \tilde{\mathrm{R}}_{2(i)} \\ \vdots \\ \vdots \\ \tilde{\mathrm{R}}_{\eta(i)} \end{bmatrix}_{\eta m\times 1},$$

$$\tilde{\mathrm{R}}_{1(i)} = \begin{bmatrix} r_{1(1i)} \pm \frac{2[1-r^2_{1(1i)}]}{\sqrt{N-2}} \\ r_{1(2i)} \pm \frac{2[1-r^2_{1(2i)}]}{\sqrt{N-2}} \\ \vdots \\ r_{1(mi)} \pm \frac{2[1-r^2_{1(mi)}]}{\sqrt{N-2}} \end{bmatrix}_{m\times 1}, \quad \tilde{\mathrm{R}}_{2(i)} = \begin{bmatrix} r_{2(1i)} \pm \frac{2[1-r^2_{2(1i)}]}{\sqrt{N-3}} \\ r_{2(2i)} \pm \frac{2[1-r^2_{2(2i)}]}{\sqrt{N-3}} \\ \vdots \\ r_{2(mi)} \pm \frac{2[1-r^2_{2(mi)}]}{\sqrt{N-3}} \end{bmatrix}_{m\times 1}, \quad \tilde{\mathrm{R}}_{\eta(i)} = \begin{bmatrix} r_{\eta(1i)} \pm \frac{2[1-r^2_{\eta(1i)}]}{\sqrt{N-\eta-1}} \\ r_{\eta(2i)} \pm \frac{2[1-r^2_{\eta(2i)}]}{\sqrt{N-\eta-1}} \\ \vdots \\ r_{\eta(mi)} \pm \frac{2[1-r^2_{\eta(mi)}]}{\sqrt{N-\eta-1}} \end{bmatrix}_{m\times 1},$$

$$\Delta\hat{\mathrm{R}} = \tilde{\mathrm{R}} - \hat{\mathrm{R}} = \begin{bmatrix} \Delta\hat{\mathrm{R}}_{1(i)} \\ \Delta\hat{\mathrm{R}}_{2(i)} \\ \vdots \\ \vdots \\ \Delta\hat{\mathrm{R}}_{\eta(i)} \end{bmatrix}_{\eta m\times 1},$$

$$\Delta\hat{\mathrm{R}}_{1(i)} = \begin{bmatrix} \pm \frac{2[1-r^2_{1(1i)}]}{\sqrt{N-2}} \\ \pm \frac{2[1-r^2_{1(2i)}]}{\sqrt{N-2}} \\ \vdots \\ \pm \frac{2[1-r^2_{1(mi)}]}{\sqrt{N-2}} \end{bmatrix}_{m\times 1}, \quad \Delta\hat{\mathrm{R}}_{2(i)} = \begin{bmatrix} \pm \frac{2[1-r^2_{2(1i)}]}{\sqrt{N-3}} \\ \pm \frac{2[1-r^2_{2(2i)}]}{\sqrt{N-3}} \\ \vdots \\ \pm \frac{2[1-r^2_{2(mi)}]}{\sqrt{N-3}} \end{bmatrix}_{m\times 1}, \quad \Delta\hat{\mathrm{R}}_{\eta(i)} = \begin{bmatrix} \pm \frac{2[1-r^2_{\eta(1i)}]}{\sqrt{N-\eta-1}} \\ \pm \frac{2[1-r^2_{\eta(2i)}]}{\sqrt{N-\eta-1}} \\ \vdots \\ \pm \frac{2[1-r^2_{\eta(mi)}]}{\sqrt{N-\eta-1}} \end{bmatrix}_{m\times 1},$$

where point estimations of correlation coefficients have an appearance:

$$\hat{\mathrm{R}} = \begin{bmatrix} \hat{\mathrm{R}}_1 \\ \hat{\mathrm{R}}_2 \\ \vdots \\ \hat{\mathrm{R}}_\eta \end{bmatrix}_{\eta m\times m}, \quad \mathrm{R}_j = \begin{bmatrix} r_{j(11)} & r_{j(12)} & \cdots & r_{j(1m)} \\ r_{j(21)} & r_{j(22)} & \cdots & r_{j(2m)} \\ \cdots & \cdots & \cdots & \cdots \\ r_{j(m1)} & r_{j(m2)} & \cdots & r_{j(mm)} \end{bmatrix}, \quad j = 1,2,\ldots,\eta .$$

Then norms of perturbations of the right member of equation (21) will take a form:

in case of $\eta < N$:

$$\delta = \left\| \Delta\hat{\mathrm{R}} \right\| = \left\| \tilde{\mathrm{R}} - \hat{\mathrm{R}} \right\| = 2\left[\sum_{j=1}^{\eta}\sum_{i=1}^{m}\sum_{k=1}^{m} \frac{|1-r^2_{j(ki)}|^2}{N-j-1} \right]^{1/2}, \quad (26)$$

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 8 , August 2016

in case of $\eta \geq N$:

$$\delta = \left\| \Delta\hat{R} \right\| = \left\| \tilde{R} - \hat{R} \right\| = \frac{2}{\sqrt{N-2}} \left[\sum_{j=1}^{\eta} \sum_{i=1}^{m} \sum_{k=1}^{m} |1 - r_{j(ki)}^2|^2 \right]^{1/2}. \quad (27)$$

The assessment $\hat{S}$ can be defined on the basis of expression

$$\hat{S} = (D + \alpha I)^{-1} \cdot \hat{R},$$

at the same time for determination of parameter of regularization α on a discrepancy, the assessment can be used

$$\alpha \leq \frac{\delta \|D\|^2}{\left\|\hat{R}_\delta\right\| - \delta}.$$

It is known [17,20,21] that without attraction of additional information on the required decision S or on exact data of the task $(D, \overline{R})$ the method of a discrepancy can't provide the accuracy of approximate solution better, than $O(\delta^{1/2}) : \left\|S_\delta - \overline{S}\right\| \geq const \cdot \delta^{1/2}$. The similar situation develops also when using a method of regularization of M.M.Lavrentyev in which the best obtainable accuracy is $O(\delta^{2/3})$ how regularization parameter was selected.

IV. CONCLUSION

The received expressions (26) and (27) allow without making the direct decision to evaluate an error of the solution of the equation (21) in case of interval estimation of elements of the right part. On expressions (26) and (27) it is also possible to obtain prior information on a decision error order for receiving qualitative outputs about with what accuracy it is reasonable to solve system further.

REFERENCES

[1] The reference manual according to the theory of automatic control / Under the editorship of A.A. Krasovsky. - M.: Science, 1987. - 712 p.
[2] Egupov N.D., K.A's Navels. Methods of the classical and modern theory of automatic control. The textbook in 5 volumes. - M.: MGTU publishing house of N.E. Bauman, 2004.
[3] Alexandrov A.G. Optimum and the adaptive systems. – M.: 2003. 278 p.
[4] Bobtsov A.A., Pyrkin A.A. The adaptive and robust control with compensating of uncertainties. – SPb.: NIUITMO, 2013. – 135 p.
[5] Afanasyev V.N. Control of indefinite systems. – M.: RUDN, 2008. – 325 p.
[6] Miroshnik I.V., Nikiforov V. O., Fradkov A.L. Non-linear and adaptive control by difficult dynamic systems. – SPb.: Science, 2000, – 549 p.
[7] Nikiforov V. O., O.V., Ushakov A.V. Is merged. Intellectual control in the conditions of uncertainty: – SPb: St.Petersburg State University of ITMO, 2011. – 226 p.
[8] Yemelyanov S.V., Korovin S. K. New types of back coupling: Control in case of uncertainty. — M.: Science. Fizmatlit. 1997. – 352 p.
[9] Yemelyanov S.V., Korovin S. K. Observers of a status for indefinite systems. Mathematical simulation. Problems and results. – M.: Science, 2003. – P. 12-35.
[10] Beetroots M.V., Konovalov A.S. Constructioning of intelligent regulators//Management information systems. №. 6/2003. – P. 25-33.
[11] Filtering and stochastic control in dynamic systems. / Under the editorship of K. T. Leondes Lane with English, - M.: Patterns, 1980. - 407 p.
[12] Ogarkov M.A. Methods of statistical estimation of parameters of accidental processes. – M.: Energoatomizdat, 1990. –208 p.
[13] Vasilyev F.P. Optimization methods. Publishing house: Factorial Press, 2002.-824 p.
[14] Lapchik M.P., Ragulina M.I., Henner E.K. Numerical methods. Publishing house: Academy, 2004. - 384 p.
[15] Biryukov S.I unsociable persons. Optimization: Theory elements: Numerical methods: Manual for higher education institutions. 2003.-248 p.
[16] Volkov E.A. Numerical methods. Publishing house: Fallow deer, 2007.-538 p.
[17] Tikhonov A.N., Arsenin V. Ya. Methods of the solution of incorrect tasks, M.: Science, 1979. –288 p.
[18] Vaynikko G. M., Veretennikov A.YU. Iterative procedures in incorrect tasks. M.: Science, 1986. –188 p.
[19] Volgin V. V., R. N. Otsenk's Karimov of correlative functions in industrial management systems. – M.: Energy, 1979. – 80 p.
[20] Bakushinsky A.B., Goncharsky A.V. Iterative methods of the solution of incorrect tasks. M.: Science, 1989. –128 p.
[21] Ivanov V. K., Vasin V. V., Tanana V.P. Theory of the linear incorrect problems and its application, M.: Science, 1978. –206 p.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 8 , August 2016

AUTHOR'S BIOGRAPHY

Mamirov Uktam Farkhodovich - Senior researcher in Department of "Intellectual engineering systems", Tashkent State Technical University, named after Abu Raikhan Beruni. More than 20 scientific articles in scientific and technical journals and publications.

Zaripov Oripjon Olimovich – Doctor of technical sciences, Professor of Department of "Intellectual engineering systems", Tashkent State Technical University named after Abu Raikhan Beruni. Author of 2 monograph, more than 5 textbooks, 8 patents and more than 180 articles in scientific and technical journals and publications.