Chemical Technology, Control and Management

Volume 2019 | Issue 5 Article 7

12-28-2019

Sustainable Algorithms For Generalized Estimation Of Dynamic Control Objects

Yulduz Muhtarhodjaeva Abdurakhmanova
Tashkent university of information technologies, Departament of Algorithmization and mathematical modeling, Republic of Uzbekistan Tashkent, 100200, Amir Temur street, 108

ISSN 1815-4840
CHEMICAL TECHNOLOGY. CONTROL AND MANAGEMENT
2019, №6 (90) pp.57-63
International scientific and technical journal
journal homepage: https://uzjournals.edu.uz/ijctcm/
Since 2005

SUSTAINABLE ALGORITHMS FOR GENERALIZED ESTIMATION OF DYNAMIC CONTROL OBJECTS

Abdurakhmanova Yulduz Muhtarhodjaeva

Tashkent university of information technologies, Departament of Algorithmization and mathematical modeling Republic of Uzbekistan Tashkent, 100200, Amir Temur street, 108

Abstract: *The problems of separate and generalized assessment of the state and parameters of controlled objects under conditions of varying degrees of a priori uncertainty are considered. Stable algorithms for the generalized estimation of the state and parameters based on the quasilinearization method and the formal model of motion under conditions of statistical uncertainty, as well as the correction of the results of the generalized estimation, are presented. It is shown that the considered regularized generalized coordinate and parametric estimation algorithms make it possible to recover with sufficient accuracy the extended state vector of a dynamical system. The above algorithms make it possible to stabilize the procedure for estimating the state of stochastic objects and thereby increase the accuracy of determining the true estimate of the state vector when the parameters of the object and observer are perturbed.*
Key words: *dynamic control object, a priori uncertainty, coordinate and parametric estimation, adaptation, regularization.*

Аннотация: *Мавҳум тескари матрица концепцияси асосида ноаниқ динамик тизимлардаги параметрлар матрицасини ва ғалаёнли ковариацион векторларни турғун баҳолаш усулларини шакллантириш алгоритмлари келтирилган. Турғун мавҳум тескари матрицалар учун соддалашган мунтазамлаштиришдан фойдаланиш орқали матрицани блокларга ажратиш усулларидан фойдаланилган. Келтирилган алгоритмлар динамик тизимлардаги параметрлар матрицасини ва ғалаёнли ковариацион векторларни турғун баҳолашни ишлаб чиқишда ҳамда параметрик ва сигналли ноаниқликлар шароитида ишлаётган адаптив бошқариш системаларини аниқлигини оширишда фойдаланилади.*
Таянч сўзлар: *ноаниқ тизим, тизим параметрлари, ғалаёнли ковариацион вектор, турғун баҳолаш, мунтазамлаштириш.*

Аннотация: *Приводятся алгоритмы формирования процедуры устойчивого оценивания матриц параметров и ковариаций векторов возмущений в неопределенных динамических системах на основе концепций псевдообращения матриц. Для устойчивого псевдообращения используется метод разбиения матрицы на блоки с использованием упрощенной регуляризации. Приведенные алгоритмы позволяют производить устойчивое оценивание матриц параметров и ковариаций векторов возмущений в динамических системах и тем самым повысить точность систем адаптивного управления, функционирующих в условиях параметрической и сигнальной неопределенности.*
Ключевые слова: *неопределенная система, параметры системы, ковариация вектора возмущений, устойчивое оценивание, регуляризация.*

Introduction

The decision of the problem recurrence estimation conditions of the linear systems if and when the known both structure, and parameters of the object, presents itself traditional equations of the filter Kalman-Biyusi [1,2]. The real conditions of the work filter are always characterized by certain degree to uncertainties to a priori information that is conditioned both impossibility of the exact description dynamic system characteristic, and incidental their time histories. This defines need united or joint estimation parameter and conditions. In literature of such sort estimation names also generalised. Such problems inevitably carry the nonlinear nature [1]. Their traditional decision is built on method markov’s theories to nonlinear filtering [3], invariant submersion [4], quasi linearization [4,5] and minimaxes of the approach [6]. In spite of theoretical motivated buildings optimum in classical sense algorithm estimation, their practical realization in row of the events is little efficient.

Problem Statement

The attempts of the decision of the problem of the provision to practical convergence algorithm estimation was undertaken, basically, toward syntheses adaptive and sub optimum filter [1-3]. The main defect, complicating practical introduction adaptive algorithm, are need for significant equipment- computing expenses and determined evristiction, which is conditioned absence beside most such algorithm united general approach to process of the adaptation. Sub optimum algorithms unlike adaptive possess the greater constructive and allow greatly to reduce the volume of the calculations under estimations. One of the most efficient methods of the syntheses adaptive and sub optimum filter is founded on method estimation on criterion of the maximum to a posteriori probability. However under practical exhibits quality to filtering, delivered these algorithm, not always turns out to be acceptable. This is conditioned that that in task of the models of the object of control, used in algorithm of the filtering, inevitably are present the mistakes. Need of the development efficient modification recurrence filter Kalman's type appears for destruction actions of the specified reasons.

The existing state of affairs is aggravated with that many problems uniform or generalized estimation conditions of dynamic systems are badly caused, thus the condition of existence of the decision, its uniqueness or stability in relation to external indignations often is not satisfied. In such situation the problem of synthesis of methods and algorithms uniform estimation is expedient for considering from the point of view of the theory regular estimation [7-13], defining methodology of construction of steady algorithms of data processing. However transition from the general operational equations to concrete constructive methods frequently not trivial also represents essential theoretical and applied interest. In this connection development regularization uniform algorithms coordinate and parametrical estimation objects of control on the basis of complex use of concepts of return problems of dynamics [14] and a method regularization [7], focused on modern opportunities of computer facilities, is represented rather actual. The complex of adaptive algorithms separate and generalized estimation conditions and parameters with reference to problems of synthesis of control systems has been developed by dynamic objects. Below some of them are resulted.

Solution

Algorithms generalized estimation at presence of mistakes in model of object of control.

Let the equations describing dynamics of object of control, look like:

$$x_k^p = F_k(x_{k-1}^p, u_{k-1}) \quad (k = 1, 2, ...), \tag{1}$$

where x_k^p – generalized vector of coordinates of a condition of object during the discrete moment of time k; F_k - known a vector-function of the arguments; u_k - operating influence.

The equation of process of measurements looks like

$$z_k = z_k(x_k, v_k) \quad (k = 1, 2, ...), \tag{2}$$

where – z_k – vector of measured coordinates; v_k – vector of mistakes of measurement. Aprioristic density of distribution of vectors rely known x_0, v_k.

The algorithm of control is set in the form of

$$u_k = u_k(\hat{x}_k), \tag{3}$$

where $\hat{x}_k$ – estimation of x_k a vector of coordinates of the condition, received in k-th the moment of time on recurrent algorithm of a filtration Kalman's type

$$\hat{x}_k = \hat{x}_{k/k-1} + K_k(y_k - \hat{z}_{k/k-1}). \tag{4}$$

In algorithm (4) $\hat{x}_{k/k-1} = \hat{x}_{k/k-1}(\hat{x}_{k/k-1}, u_{k-1})$, $\hat{z}_{k/k-1} = \hat{z}_{k/k-1}(\hat{x}_{k-1}, u_{k-1})$ – estimations of vectors x_k, z_k defined according to $\hat{x}_{k-1}, u_{k-1}$ about managerial process; K_k – factor of strengthening of the filter. At the decision of a problem of synthesis of system for construction of algorithm of control (3) the simplified equations of object of a kind are rather often used: $x_k = F_k^*(x_{k-1},\ u_{k-1})$. Thus a vector-function $F_k^* = (F_k^{*1}, F_k^{*2}, \ldots, F_k^{*n})$ gets out whenever possible more simple that errors of definition of coordinates of object from replacement F_k on F_k^* did not surpass the set sizes. Also the equation of measurements (2): $z_i = z_i^*(x_i,\ v_i)$ accordingly becomes simpler. A considered problem usually solve on the basis of known methods linearization. Lack noted above variants of the filter consists that accuracy of control obviously decreases because of are nonviscous between F_k and F_k^*, z_k and z_k^*. Therefore it is represented expedient believing in algorithm (4) $\hat{x}_{k/k-1} = F_k^*(\hat{x}_{k-1}, u_{k-1})$, $\hat{z}_{k/k-1} = z_k^*(x_{k/k-1}, v_k = 0)$ weight matrix K_i to define directly from the equation [15]:

$$K_k \Gamma_k = \Lambda_k \ \ (k = 1, 2, \ldots), \tag{5}$$

or

$$\sum_{t_1=1}^{m} k_k^{st} \gamma_k^{t_1 t} = \lambda_k^{st} \ \ (t = 1, 2, \ldots, m;\ s = 1, 2, \ldots, n). \tag{6}$$

In (6) λ_k^{st} and $\gamma_k^{t_1 t}$ – an essence elements of matrixes of the mixed initial moments of the second order of vectors $x_k - \hat{x}_{k/k-1}$ and $z_k - \hat{z}_{k/k-1}$, and vectors $z_k - \hat{z}_{k/k-1}$ accordingly, and k_k^{st} – elements of a matrix K_k.

The equation (5) we shall solve iterative methods [11-13]. For this purpose it is used the following iterative scheme: $k_{k,r}^j = k_{k,r-1}^j - g_\alpha\left(\Gamma_k^T\right)\left(\Gamma_k^T k_{k,r-1}^j - \lambda_k^j\right),\ r = 1,2,\ldots,$ where $g_\alpha\left(\Gamma_k^T\right) = \left(\Gamma_k^T + \alpha I\right)^{-1}$, $g_\alpha(\lambda) = (\alpha + \lambda)^{-1}$, $0 \le \lambda \le \infty$, $k_{k,r}^j$ and λ_k^j – j-th column of the matrixes K_k^T and Λ_k^T accordingly ($j = 1,2,\ldots n$).

Because of errors of a rounding off or any other handicapes on each step of iterations discrepancies are supposed, and real calculations it is possible prototypes the iterative scheme of a kind:

$$\tilde{k}_{k,r}^j = \tilde{k}_{k,r-1}^j - g_\alpha\left(\Gamma_k^T\right)\left(\Gamma_k^T \tilde{k}_{k,r-1}^j - \lambda_k^j\right) + w_{k,r},\ r = 1,2,\ldots, \tag{7}$$

where $w_{k,r}$, $r \ge 1$ – small indignations in any sense. We shall consider here, that $\|w_{k,r}\| \le \varepsilon$, where ε – small positive parameter.

Induction on r it is possible to come to expression

$$\tilde{k}_{k,r}^j - k_*^j = \left(I - \Gamma_k^T g_r\left(\Gamma_k^T\right)\right)^r \left(k_0^j - k_*^j\right) + g_r\left(\Gamma_k^T\right)\left(\lambda_k^j - \Gamma_k^T k_*^j\right) + \sum_{j=0}^{r-1}\left(I - \Gamma_k^T g_\alpha\left(\Gamma_k^T\right)\right)^j w_{k,r-j}.$$

Thence $\left\|\tilde{k}_{k,r}^j - k_*^j\right\| \le \left\|\left(I - \Gamma_k^T g_r\left(\Gamma_k^T\right)\right)^r \left(k_0^j - k_*^j\right)\right\| + r\varepsilon$. Possible show that $\tilde{k}_{k,r(\varepsilon)}^j \to k_*^j$ under $\varepsilon \to 0$, where k_*^j – nearest to $\tilde{k}_0^j \to k_0^j$ quasi decision of the equation (5) if iterations (7) stop on such $r = r(\varepsilon)$, that $r(\varepsilon) \to \infty,\ \varepsilon r(\varepsilon) \to 0$ under $\varepsilon \to 0$.

Algorithms estimation a vector of indignations in problems of the generalized filtration.

We shall consider the object of control described certainly-differencenly by the equations

$$x_k = f_k(x_{k-1}, u_{k-1}, w(k)),\ k = 1,2,\ldots, \tag{8}$$

$$y_k = f_k^*(x_k, W(k), h(k)),\ k = 1,2,\ldots. \tag{9}$$

Sequence of casual vector processes $w(k), W(k), h(k)$ in (8), (9) we approximate a piece of some decomposition on known not casual coordinate functions $q_n(k)$ and $q_n^*(k)$ with casual factors $\omega^{(n)}$ and $W^{(n)}$:

$$w(k)=\sum_{n=1}^{N_1}\omega^{(n)}q_n(k),\ w=(\omega^{(1)},\omega^{(2)}...\omega^{(N_1)}), \tag{10}$$

$$W(k)=\sum_{n=1}^{N_2}W^{(n)}q_n^*(k),\ W=(W^{(1)},W^{(2)},...W^{(N_2)}),\ h(k)=\sum_{j=1}^{I}h_j\delta_j(k),\ \delta_j(k)=\begin{cases}1, \text{under } j=i\\ 0, \text{under } j\neq i,\end{cases} \tag{11}$$

where $W(k)$- forming mistakes of the measurement; $h(k)$ - forming type of the vector discrete white noise; $h(k)$- casual vector.

Using indication of the type $\bar{Z}_i \stackrel{\Delta}{=} (z_1, z_2,..., z_i)$, as given to models

$$\bar{y}_k = \bar{F}(V, \bar{u}_{k-1}),\quad k=1,2,..., \tag{12}$$

object of control shall take sequence a vector-function $y_j = F_j(x_0, u_{k-1}, w, W, h_j)$ $j=1,2,...,$ got as a result of foldings of the correlations (8)-(11). In (12) $V=(x_0, w, W, \bar{h}_I)$ - vector, uniting all casual factors constant in realization of the process of control [16]. For determination of the vector of the indignations V we use equation of the type

$$\psi(V)=Sp(B^*\bar{e}\bar{e}^{\mathrm{T}}), \tag{13}$$

where $\bar{e}=\bar{y}-\bar{y}^0 -$ matrix it is nonviscous; B^* – diagonal matrix of positive factors by means of which function is led to the dimensionless form; *Sp*- trace of the matrix. Being based on conditions of the accepted assumptions according to a principle iterative regularization [11,12] it is possible to write out following iterative sequence:

$$V_{r+1}=P_Q\left(V_r-\alpha_r\left(\psi'(V_r)+\varepsilon_r V_r\right)\right), \tag{14}$$

where P_Q - operator of the designing.

It is shown, that iterative process (14) converges to the decision of a problem (13) with the minimal norm, thus as sequences α_r and ε_r sequences of a kind can serve: $\alpha_r=(1+r)^{-1/2},\ \varepsilon_r=(1+r)^{-p},\ 0<p<1/2$.

The algorithms to correction result generalised estimation.

We shall consider object of control, described by equations

$$x_{k+1}=f_k(k, x_k, u_k, \psi_k),$$
$$z_k=g_k(k, x_k, d_k, \varphi_k),$$

where ψ_k – vector unknown influence on object; d_k – vector of known influences, naturations adaptation of the channel of supervision; φ_k – vector unknown influence on channel of the observation.

Known [17] that considered problem is reduced to minimization of the square-law form of the type $\nabla(D)=H^T(D)H(D)$, where $H(D)=[h_i[\hat{x}_{k_0}^p, D],...,h_i[\hat{x}_{k_{N-1}}^p, D]]^T$. The required estimation $\widehat{D}$ is from a condition $\dfrac{\partial\nabla(\widehat{D})}{\partial\widehat{D}}=\varsigma^T(\widehat{D})H(\widehat{D})=0$, where $\varsigma(\widehat{D})=\partial H(\widehat{D})/\partial\widehat{D}$. It is shown, that for calculation of a vector of unknown factors $\widehat{D}$ it is expedient to use following regular iterative procedures:

$$\widehat{D}_{(j)}=\widehat{D}_{(j-1)}+\lambda_j\left(\widehat{\varsigma}^T_{(j-1)}\widehat{\varsigma}_{(j-1)}+\alpha_j I\right)^{-1}\widehat{\varsigma}^T_{(j-1)}H(\widehat{D}_{(j-1)}),\ j=\overline{1,J_0},\lambda_j>0,\ \alpha_j=B(k+1)^{-1}, B>>0,$$

$$\widehat{D}_{(j)}=\widehat{D}_{(j-1)}+\lambda_j\left(\widehat{\varsigma}^T_{(j-1)}\widehat{\varsigma}_{(j-1)}+\alpha_j\Gamma_j\right)^{-1}\widehat{\varsigma}^T_{(j-1)}H(\widehat{D}_{(j-1)}),\quad \Gamma_j=diag\left(\widehat{\varsigma}^T_{(j-1)}\widehat{\varsigma}_{(j-1)}\right).$$

The algorithms generalised estimation on base of the method to quasi linearization.

We shall consider problem estimation generalised vector x_k^p dynamic systems

$$x_{k+1}^p = f(x_k^p, k) + w_k \tag{15}$$

on result of the measurements of the output signal $z_k = h(x_k^p, k) + v_k, \quad k \in [0, k_N]$. In row of the problems generalised estimation necessary to find the initial path of the moving the dynamic system. One of the most efficient methods of estimation dynamic systems is an indirect computing method the known under name of the method to quasi linearization [4,5].

According to method quasi linearization necessary to find path x_k, $k \in [k_0, k_f]$, which satisfies nonlinear not autonomous n-measured difference to equation (15) and system linearizations equations of the observations of the type $z'_{k_j} = C^i_{k_j} x^{i+1}_{k_j} + v_{k_j}$, $j = 1,2,...,m$, where $z'_{k_j} = z_{k_j} - h\left[\hat{x}^i_{k_j}, k_j\right] + C^i_{k_j}\hat{x}^i_{k_j}$, $C^i_{k_j} = \frac{\partial h[\hat{x}^i_k, k_j]}{\partial \hat{x}^i_k}$. It is expected that initial estimation to paths $\hat{x}^i_k$ known. Problem consists in selection such $\hat{x}^{i+1}_{k_0}$, which minimizes functional

$$J = \sum_{j=1}^{m} \left\| z_{k_j} - h\left[\hat{x}^i_{k_j}, k_j\right] - \frac{\partial h[\hat{x}^i_k, k_j]}{\partial \hat{x}^i_k}\left[\hat{x}^{i+1}_{k_j} - \hat{x}^i_{k_j}\right] \right\|^2 = \sum_{j=1}^{m} \left\| z'_{k_j} - C^i_{k_j}\hat{x}^{i+1}_{k_j} \right\|^2 .$$

Possible show that estimation $\hat{x}^{i+1}_{k_0}$ can be found as decision of the following system of the equations: $M^{i+1}\hat{x}^{i+1}_{k_0} = N^{i+1}$, where matrix M^{i+1} and vector N^{i+1} are defined on base of the decomposition vector-function $f(x_k^p, k)$ and $h(x_k^p, k)$ in row Taylor and corresponding to transformations result decompositions. Knowing $\hat{x}^{i+1}_{k_0}$, possible define whole path $\hat{x}^{i+1}_k$ and repeat the calculations while the next approach not restrain are powerfully changed.

One of the computing difficulties, in accordance with this method, consists in degenerations or bad conditioned matrixes M^{i+1}. This circumstance predestines using the methods regularization. Regularizations estimation $\hat{x}^{i+1}_{k_0}$ shall find on base of the method simplified regularization M.M.Lavrentiev's: $\hat{x}^{i+1}_{k_0} = \left[M^{i+1} + \alpha I\right]^{-1} N^{i+1}$. For choice of the parameter regularization α here reasonable use necessary numerical scheme with using quickly reconverging iteration methods of the decision of the equations of the type of the method tangent Newton [8,18-20]: $r = 0,1,...,$ where initial importance $r_{i+1,0}$, is chosen so that $0 \le r_{i+1,0} \le r_\Delta$, $\alpha = 1/r$; θ – priori assigned level of possible importance of the function $\rho_0(r) = \left\| M^{i+1}\hat{x}^{i+1(r)}_{k_0} - N^{i+1} \right\|$.

The algorithms generalised estimation on base of the formal model of the motion.

We shall consider formal model of the moving the object of the type

$$y(t) = \sum_{s=0}^{S-1} d_s \theta_s(t) . \tag{16}$$

The formula (16) will assign the linear combination known independent function with parameter $d_0, d_1, ..., d_{S-1}$, subjecting to determination. Equation of the observation shall receive a visit at type $z_{lp} = y_p^{(l)} + v_{lp}$, $l = \overline{0, L-1}$, $p = \overline{0, P-1}$, where $y^l(t)$ - derived by law of the moving the object in point $t_0, t_1, ..., t_{P-1}$, $y_p^l(t) = d^l y(t)/dt^l \big|_{t=t_p}$ [21-23].

Write rate nonviscous $J = \|z - y\|^2 = [z - \Theta d]^T [z - \Theta d]$, where $z = \{z_0, z_1, ..., z_{L-1}\}^T$, $z_j = \{z_{j0}, z_{j1}, ..., z_{j,P-1}\}$, $j = \overline{0, L-1}$, $\Theta = \{\theta_0, \theta_1, ..., \theta_{L-1}\}^T$, $\theta_j = \{\theta^{(j)}_{ps}, p = \overline{0, P-1}, s = \overline{0, S-1}\}^T$,

$y=\{y_0,y_1,...,y_{L-1}\}^T$, $y=\{y_0^{(j)},y_1^{(j)},...,y_{P-1}^{(j)}\}^T$, $d=\{d_0,d_1,...,d_{S-1}\}^T$. Minimization functional brings about equation

$$\Theta d = z. \tag{17}$$

The known that given inverse problem pertains to class incorrect since system of the linear algebraic equations (17) tends to loss conditioned with increase the order to models (16). Conditions to aproximations of the raw datas shall receive a visit at type: $\|\Theta_h-\Theta\|\le h, \|z_\delta - z\|\le\delta$.

For finding the decision of the equation (17) use method of regularization A.N.Tihonov, which corresponds to generating system a function $g_\alpha(\lambda)=(\alpha+\lambda)^{-1}, \alpha>0, 0\le\lambda<\infty$. We shall use following approach $d_\alpha = B_{\alpha h} z_\delta$, $\bar{d}_\alpha=\bar{B}_{\alpha h} z_\delta$, where $B_{\alpha h}=g_\alpha(\Theta_h^T\Theta_h)\Theta_h^T=(\Theta_h^T\Theta_h+\alpha I)^{-1}\Theta_h^T$, $\bar{B}_{\alpha h}=B_{\alpha h}\Theta_h B_{\alpha h}$.

Iteriration variant of the method A.N.Tihonov write as

$$d_{n,a}=(\Theta_h^T\Theta_h+\alpha I)^{-1}(\alpha d_{n-1,\alpha}+\Theta_h^T z_\delta),\ n=1,...,m, \tag{18}$$

$$\bar{d}_{n,a}=(\Theta_h^T\Theta_h+\alpha I)^{-1}(\alpha \bar{d}_{n-1,\alpha}+\Theta_h^T \Theta_h d_{m,\alpha}),\ n=1,...,m. \tag{19}$$

As drawn near decisions of the equation (20) are taken $d_r=d_{m,\alpha}$ and $\bar{d}_r=\bar{d}_{m,\alpha}$ ($r=\alpha^{-1}$), herewith

$$B_{rh}=B_{\alpha h}^{(m)}=\sum_{j=2}^{m-1}\alpha^j(\Theta_h^T\Theta_h+\alpha I)^{-(j+1)}\Theta_h^T,\ \bar{B}_{rh}=\bar{B}_{\alpha h}^{(m)}=B_{\alpha h}^{(m)}\Theta_h B_{\alpha h}^{(m)}.$$

Possible show that iteriration variant of the method A.N.Tihonov several more exactly not iterations. More essential is that circumstance that parameter α no need to take so small, as in not iterations variant. This allows to enlarge stability of the calculations. Parameter regularization r in (18), (19) by reasonable a posteriori image to select so that $\|\Theta_h d_r - z_\delta\| = b(\delta+\|d_r\|h), b>1$.

Conclusion

For the reason analysis of efficiency brought regular algorithm generalised estimation was solved multiple toy problems. They were considered problems separate and generalised estimation conditions and parameter operated object in condition different degree to a priori uncertainty. It is shown that considered regularization generalised algorithms coordinate and parametric estimation allows with sufficient accuracy to restore the extended vector of the condition of the dynamic system. Offered regular algorithms generalised estimation has found using at decision of the varied practical problems to identifications, estimation and control concrete technological object.

References:

1. The directory under the theory of automatic control / Under redaction A.A.Krasovskiy. - M.: Science, 1987. - 712 p.
2. Filtration and stochastic control in dynamic systems. / Under redaction K.T.Leondes. Trans. from English., - M.: World, 1980. - 407 p.
3. Yarlikov M.S. Using Markov theories to nonlinear filtering in radio mechanic. M.: Radio, 1975.
4. Andrew P.Sage, James L.Melsa. System identification.-M.: Science,1974.-248 p.
5. Eykhoff P. Bases to identifications managerial system. M.: World,1975.- 683p.
6. Repin V., Tarkovskiy G. Statistical syntheses under a priori uncertainty and adapting the information systems. -M.: Radio, 1997.
7. Tihonov A.N., Arsenin V.Y. Method of the decision of incorrect problems. - M.: Science, 1979. - 288 p.
8. Morozov V.A. Regular methods of the decision it is incorrect tasks in view. - M.: Science, 1987. - 240p.
9. Yusupbekov N., Igamberdiev H., Mamirov U. Algorithms Of Sustainable Estimation Of Unknown Input Signals In Control Systems // Journal of Automation, Mobile Robotics & Intelligent Systems. 2018. Vol. 12. – №. 4. –PP. 83-86.
10. Igamberdiyev H.Z., Yusupbekov A.N., Zaripov O.O., Sevinov J.U. Algorithms of adaptive identification of uncertain operated objects in dynamical models // Procedia computer science. 2017, Vol. 120. – PP. 854-861.
11. Vasiliev F.P. The Methods to optimization. Publishers: Factorial Press, 2002. -824 p.
12. Bakushinskiy A.B., Goncharskiy A.V. Iterative methods of the decision of incorrect problems. M.: Science, 1989.- 128p.
13. Vaynikko G.M., Veretennikov A.Yu. Iteration procedures in incorrect exercises . - M.: Science, 1986. – 178 p.
14. Crutko P.D. Inverse problems speakers operated systems.-M.: Science,1987.- 304p.

15. Homyakova L.M. To problem of the filtering in nonlinear managerial system // Automation and telemechanics, 1979, №1. -pp.65-71.
16. Andrienko A.Y. Method of estimations vector of the indignations to high dimensionality in problem of the forecasting of the final condition terminal managerial system // Automation and telemechanics, № 7, 1996.-pp. 71-81.
17. Igamberdiyev H.Z., Mamirov U.F. Sustainable estimation of parameters and covariation of disturbance vectors in uncertain systems // Chemical Technology. Control and Management. 2018. № 3. – PP. 16-19.
18. Zhdanyuk B.F. Bases of the statistical processing path measurements.- M.: Radio, 1978.
19. Burlay I.V. Parametrical identification of the operated systems on the base of the extended model of the observations // Notify Academies of the sciences. The theory and managerial system, №4, 1997. –pp.29 -34.
20. Burlay I.V. The regular methods of estimation condition object in dynamic and kinematicses to production // Notify academies of the sciences. Theory and managerial system, №3, 2000. –pp.17-23.