Algorithms for Control of Dynamic Objects Based on Adaptive Filtering Methods

Zaripova Shahlo Olimovna

Assistant of the Department of Information technologies, Karshi engineering economics institute, zaripovashahlo87@gmail.com, tel.: 91-956-07-50

ABSTRACT

The article presents algorithms for managing dynamic objects based on adaptive filtering methods. A functional diagram of an adaptive system for dynamic control of technological processes is proposed. For the values of the adaptive filter size, the relationship between the sum of squares of the correlation coefficient and the signal error obtained as a result of filtering the original useful signal is obtained. The proposed adaptive control system makes it possible to stabilize the mode of technological parameters of the process, improve the quality of products and the productivity of the unit. These algorithms make it possible to use dynamic production objects in automation and control tasks.

Keywords: adaptive estimation, adaptive filters, coefficients, dynamic objects, regularity parameter, control effect, ill-posed problem, iterative regularization principle, mathematical model, noise estimation.

Introduction. In assessing the state of technological objects, adaptive filtering is mainly used in the purification of unstable interfering signal and noise data in cases given a priori for the calculation of indeterminate, variable and parametric filters of the frequency range that fills or interferes with the desired signals. For example, in the Shurtan Oil and Gas Production Department, very strong active riots in digital communication can interfere with useful signals, while in digital transmission of data on a channel with a poor frequency characteristic, interference between symbols of digital codes can be observed. An effective solution to this problem can only be achieved with adaptive filters.

The frequency characteristics of adaptive filters are automatically adjusted or modified according to a defined criterion that allows filters to adapt to changes in the characteristics of the input signals [1-5].

Adaptive filters are used to clean signals from noise. However, adaptive algorithms depend on a feedback mechanism characterized by a sharp increase in instability in some applications.

Optimal estimation algorithms, which are now significantly developed, are the result of solving model problems with full availability of a priori statistics. In practice, however, a priori statistics are usually known only approximately or not at all. In such cases, the conditions of model problems are violated, the resulting estimation algorithms become suboptimal, and their estimates remain incomplete and scattered [6,7].

These circumstances make it necessary to ensure that the filter parameters are not specifically related to the factors mentioned above.

Formulation Of The Problem. This representation of the process allows you to choose the structure of the mathematical model in the following form:

$$x_{i+1} = A_i x_i + F_i x_{i-h} + B_i u_i + w_i \,,\; y_i = H_i x_i + v_i \,. \quad (1)$$

In order to obtain a mathematical model and use it in practice, an industrial experiment is conducted under the conditions of normative operation of the dynamic process. (1) The sought values of the matrices A_i, F_i and B_i in the equation are equal to the following for the accepted time interval[3]:

For the acquisition of mathematical models and their use in practice provoditsya promыshlennыy experiment in the conditions of normative protection of dynamic processes. Iskomye znacheniya v uravnenii (1) i matritsy ravny sleduyushchim dlya prinyatogo intervala vremeni [3]:

$$A = \begin{bmatrix} A_1 & A_2 & A_3 \\ A_4 & A_5 & A_6 \\ A_7 & A_8 & A_9 \end{bmatrix},\; F = \begin{bmatrix} F_1 & F_2 & F_3 \\ F_4 & F_5 & F_6 \\ F_7 & F_8 & F_9 \end{bmatrix},\; B = \begin{bmatrix} B_1 & B_2 & B_3 \\ B_4 & B_5 & B_6 \\ B_7 & B_8 & B_9 \end{bmatrix}. \quad (2)$$

Examination of the similarity of the developed models on the basis of the residual criterion, based on the values of the parameters in expression (2), the model (1) showed a monand description of the process under consideration [6].

In practice, a significant deviation of the composition of specific target products from their predetermined values indicates that there will be large and rapidly recurring upheavals associated with changes in the composition and consumption of raw materials [1,8].

Therefore, the issue of adaptive stabilization in the operating mode of the object is important in the management of the dynamic process. This issue is a key issue in dynamic process management in conditions of uncertainty without knowing the descriptions of external disturbing influences and the values of the parameters of the control object.

Dynamic process control is extremely complex due to nominal-phase properties such as time delays of several minutes, length of installation time, and unmeasurable changes in the properties of the parameters. We connect the regulator $u_i = \mathrm{K}_i^T z_i$ to the object (1), K - adjuster parameters of the $n \times 2l$ -dimensional matrix. Assume that the matrices A, F, V, H depend on a vector of unknown parameters $\xi \in M$, where M is the set that defines the flexibility class of the synthesized system [2,9].

To solve the problem, we obtain the following Lyapunov-Krasovsky functionality:

$$V(x_s, \mathrm{k}_s) = x_i^T L_0 x_i + \sum_{i=1}^{m} (\mathrm{k}_i - \mathrm{k}_{0i})^T L_i (\mathrm{k}_i - \mathrm{k}_{0i}) - \gamma \left[\frac{1}{2}\left(x_{i-h}^T x_{i-h} + x_i^T x_i \right) + \sum_{l=1-h}^{-1} x_{i+l}^T x_{i+l} \right],$$

where L_0, L_i are real symmetric positive matrices; k_{0i} – K_0 of the matrix *i*-column $\gamma > 0$.

It can be shown that the synthesized system is adaptive in a given class M, and the algorithm for adjusting the parameters of the regulator has the following appearance:

$$\mathrm{k}_{i+1} = \mathrm{k}_i - \mathrm{d}_i^T z_i P_i \psi_i \,,\; i = 1,2,\ldots,m \,, \quad (3)$$

where P_i –are arbitrary positively defined matrices; d_i - the *i*-column of the D matrix, which is determined by the frequency theorems of the stability of the systems; $\psi^T = z_i^T z_{i-h}^T$

The Kalman filter equation looks like this [1,4]:

$$\hat{x}_{i+1} = A_i \hat{x}_i + F_i \hat{x}_{i-h} + B_i u_i + K_i^1 [y_i - \mathrm{K}_i \hat{x}_i - \mathrm{K}_i B_i u_i] - \frac{h}{n}\left[\frac{1}{2}\left(K_{i,-h}^2 [y_{i-h} - \mathrm{K}_{i-h} \hat{x}_{i-h}] + K_{i,0}^2 [y_i - \mathrm{K}_i \hat{x}_i] \right) + \sum_{l=1-h}^{-1} K_{i,l}^2 [y_{i+l} - \mathrm{K}_{i+l} \hat{x}_{i+l}] \right]. \quad (4)$$

Amplification coefficients K_i^1 and K_i^2 determined by the following equations:

$$K_i^1 = [P_i - P_{i,0}] \mathrm{K}_i^T R_i^{-1}, \quad K_{i,s}^2 = P_{i,s} \mathrm{K}_{i+s}^T R_{i+s}^{-1} \,. \quad (5)$$

(3) – (5) based on the above algorithms developed for the synthesis of expressive and state vector adaptive evaluation systems, the following variant of the adaptive control system of the dynamic process can be proposed (Figure 1).

The proposed system of adaptive control allows to stabilize the technological parameter regime of the process, increase product quality and unit performance[2,10].

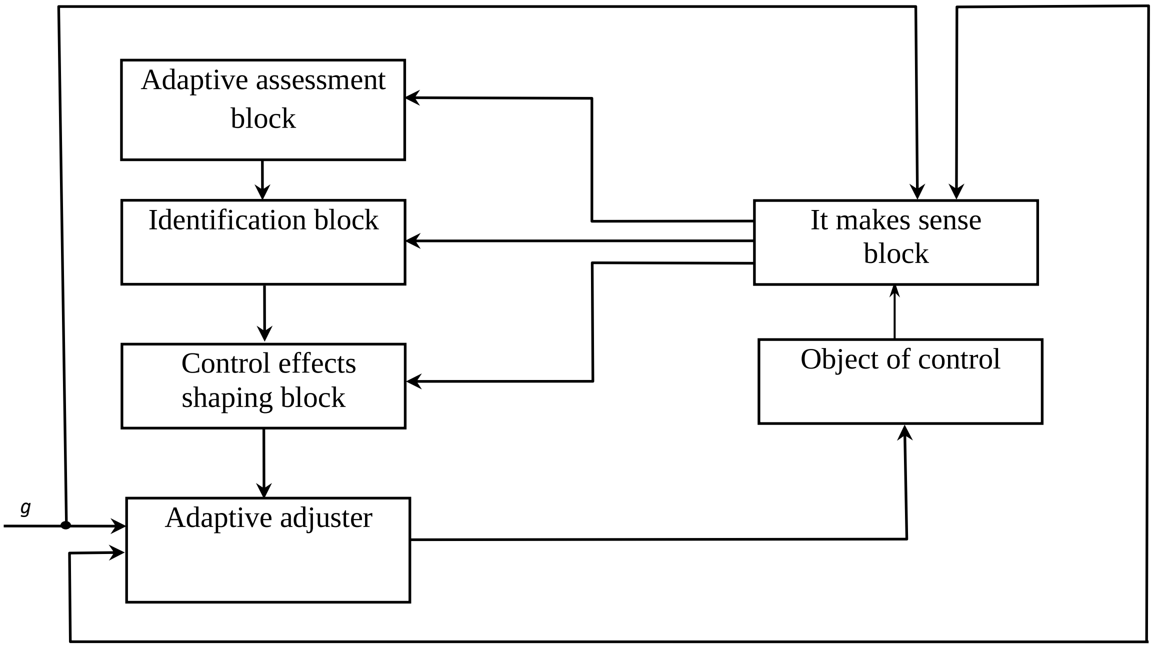

Figure 1 . ***Functional scheme of the adaptive system of dynamic process control.***

We also consider the algorithms of regular adaptive assessment through computer modeling.
A computer model was developed in the "Simulink" environment [4,11] to approximate the filtering quality from the correlation coefficient between the noisy useful signals and the noise value. The structure of the developed model is shown in Figure 2.

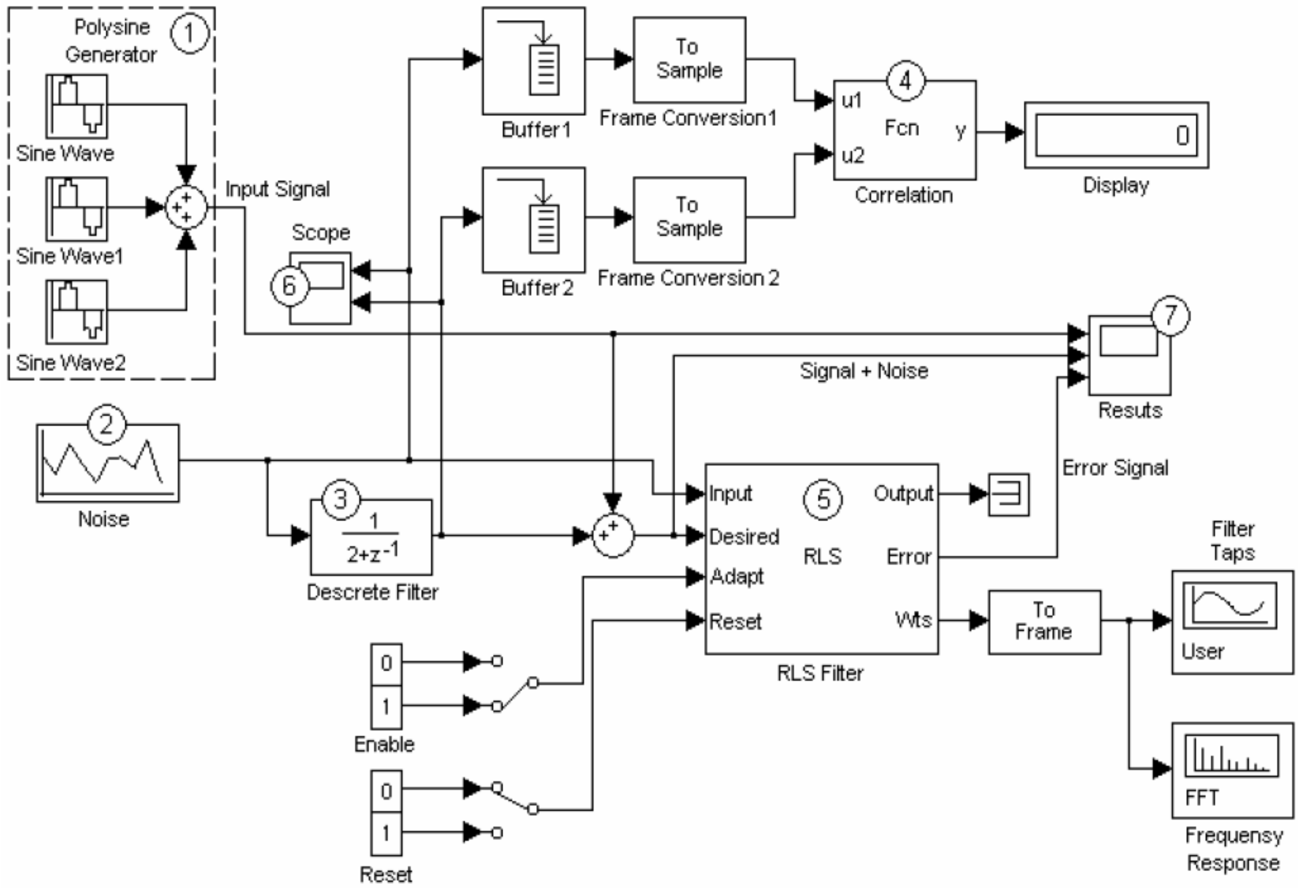

Figure 2. ***Block diagram of a dynamic process model using adaptive filters.***

The model consists of the following blocks:

1. Polyharmonic signal generation unit: $S(t)=\sum_{i=1}^{n} A_i \cos(w_i t+\varphi_i)$;
2. Noise source (white Gaussian noise).
3. Second order discrete filter;
4. $p=\frac{\operatorname{cov}(x_1, x_2)}{\sigma_{x_1}\cdot\sigma_{x_2}}$ block for calculating the correlation coefficient according to the formula;
4. Adaptive LMS or RLS filters.
5. Ostsillograph.
6. Monitor showing final results.

The results of filter adaptation (selection of coefficients) after counting 150 signals are shown in Figure 3. The coefficients of the filter are shown in Figure 3, a, and the AChX (amplitude frequency characteristic) of the filter is shown in Figure 3, b.

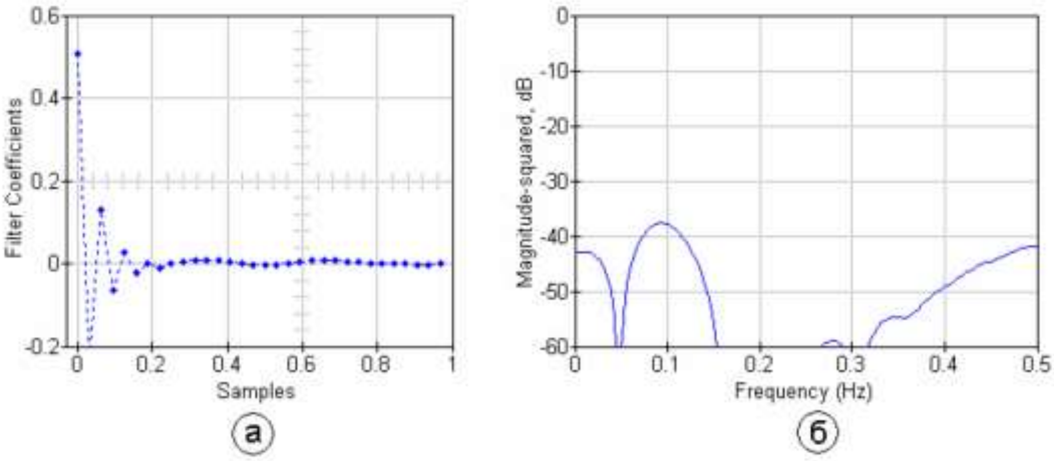

Figure 3. ***Results of the adaptation process:***
a - filter coefficients; б – filter AChX si

It can be seen from the coefficients that the order of the filter can be reduced by about 3 times for this condition. It should be noted that adaptive filters are very stable in filtering signals with the last spectrum of coefficients, and a one-time selection is required when the parameters of the influencing factors do not change over time. The second-order discrete filter (3 blocks) forms an estimate of the difference in noise from the signals in the signals, and also sets the different correlation coefficients in the model [10]. The signals at the input and output of the discrete filter (6 blocks) are shown in Figure 4.

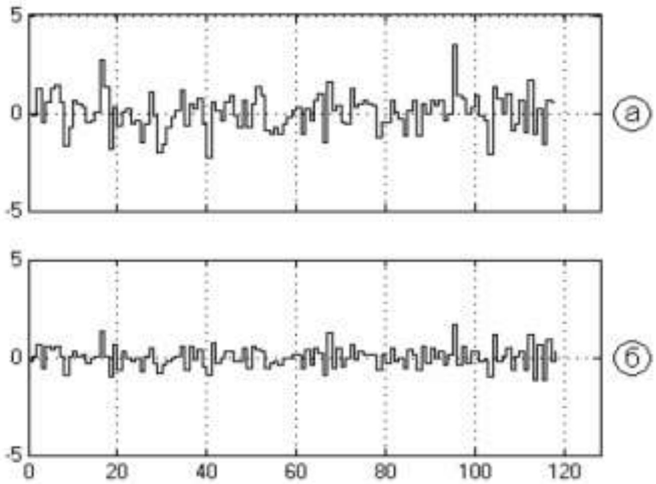

Figure 4. ***An oscillogram of noise (a) and its value (b)***

The performance results of the model presented for noisy polyharmonic signals are shown in Figure 5. The correlation coefficient is 0.87.

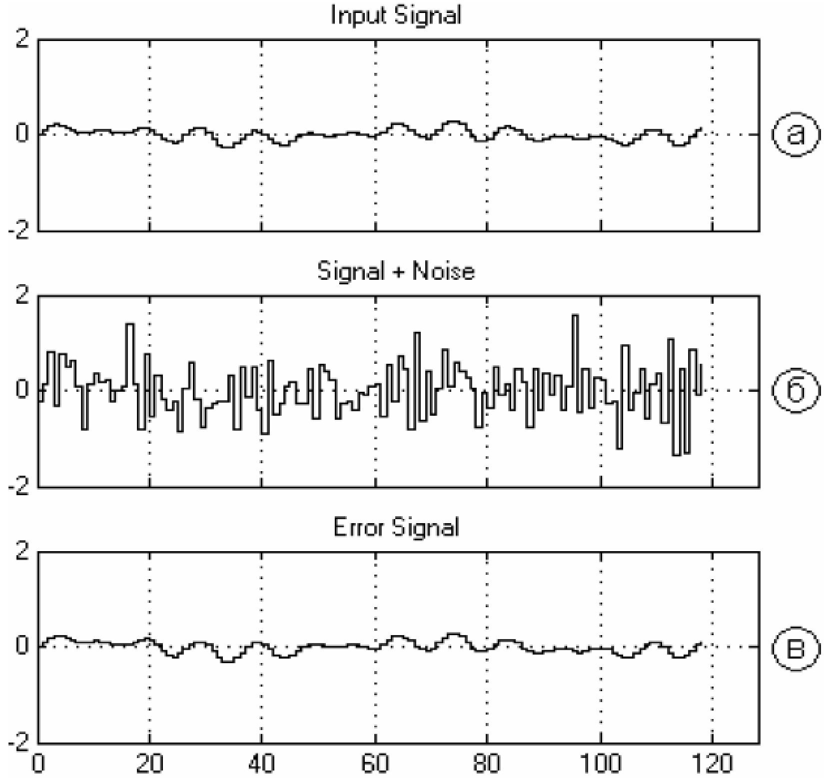

Figure 5. ***Performance oscillogram of the adaptive filter:***
a - sample signal; b - noisy (changed) signal; v- the first signal cleared of noise

As can be seen from the images, the signals are restored without distortion at a very small amplitude of the standard input signals and at a multiple increase in noise in the useful signals consisting of a change in the signals cleared from the initial noise. An average of 150 signals are required to select the filter coefficients under different conditions [5].

Conclusion. Using the given model, the relationship between the correlation coefficient and the sum of the squares of the signal error resulting from filtering from the initial useful signal for the values of the adaptive filter size was obtained. In summary, computer models of adaptive filtering based on adaptive filtering algorithms allow synthesizing evaluation and control issues, and dynamic process data can be more widely used in the field of automation of production processes of adaptive filtering algorithms.

References:

1. Sinitsyn I.N. Filter Kalmana and Pugacheva. Izd-vo: Logos, 2006. –640p.
2. Igamberdiev X.Z., Sevinov J.U., Zaripov O.O. Regular methods and algorithms for the synthesis of adaptive systems of management with nastraivaemymi models. - T .: TashGTU, 2014. - 160 p.
3. Sevinov J.U., Zaripova Sh.O. Algorithms for adaptive assessment of the state of control objects on the basis of identification approach // Scientific and technical journal of innovative technologies, QarMII. №1 (41), 2021. - 40 b.
4. Sevinov, J. U., Zaripov, O. O., & Zaripova, S. O. (2020). The algorithm of adaptive estimation in the synthesis of the dynamic objects control systems. *International Journal of Advanced Science and Technology*, *29*(5 Special Issue), 1096-1100.
5. Abidov, K. G., Zaripova, S. O., Khamudkhanova, N. B.,

Dusmukhamedova, S. A., Gafurova, M. O., & Baratov, H. (2021). Analytical mathematical model of the pumping unit of machine water lifting systems. In *E3S Web of Conferences* (Vol. 289, p. 07004). EDP Sciences.

6. Абидов, К. Г., Зарипов, О. О., & Зарипова, Ш. О. (2021). АНАЛИЗ МЕТОДИКИ РАСЧЕТА ПРИ ОПРЕДЕЛЕНИИ КОЛИЧЕСТВА ОДНОВРЕМЕННО САМОЗАПУСКАЕМЫХ НАСОСНЫХ УСТАНОВОК. *ИННОВАЦИИ В НЕФТАГАЗОВОЙ ОТРАСЛИ*, *2*(1).
7. Gulzoda, M., Giyos, M., Odiljon, Z., & Shaxlo, Z. (2020). Experimental study of the field in the gap of synchronous machine with the use of sinusoidal turns. In *E3S Web of Conferences* (Vol. 216, p. 01109). EDP Sciences.
8. Абидов, К. Г., Зарипов, О. О., & Зарипова, Ш. О. (2021). САМОЗАПУСК НАСОСНЫХ УСТАНОВОК МЕЛИОРАТИВНЫХ НАСОСНЫХ СТАНЦИЙ. *Наука, техника и образование*, (3 (78)), 19-24.
9. Abidov, K. G., Zaripov, O. O., Rakhmatullaev, A. I., Zaripov, N. O., & Zaripova, S. O. (2021). Calculation methodology for determining the number of simultaneous self-starting pumping units. In *E3S Web of Conferences* (Vol. 289, p. 07003). EDP Sciences.
10. Gayratovich, E. N., & Jovliyevich, K. B. (2023). Theory and Methodology of Software Modeling Using the Web Platform. *Eurasian Scientific Herald*, *16*, 59-63.
11. Ergashev, N. (2023). ОЛИЙ ТАЪЛИМ ТЕХНИКА ИХТИСОСЛИКЛАРИ ЎҚУВ МАТЕРИАЛЛАРИНИ ДАСТУРИЙ ВИЗУАЛЛАШТИРИШНИНГ ИЛМИЙНАЗАРИЙ АСОСЛАРИ. *Electron Library Karshi EEI*, *1*(01). Retrieved from https://ojs.qmii.uz/index.php/el/article/view/270
12. Ergashev, N. (2023). Methods of teaching parallel programming methods in higher education. *Electron Library Karshi EEI*, *1*(01). Retrieved from https://ojs.qmii.uz/index.php/el/article/view/271
13. Ergashev, N. (2023). Raqamli ta'lim sharoitida bulutli texnologiyalar yordamida oʻqituvchilarni kasbiy faoliyatga koʻp bosqichli tayyorlashning nazariy aspektlari . *Electron Library Karshi EEI*, *1*(01). Retrieved from https://ojs.qmii.uz/index.php/el/article/view/274
14. Ergashev, N. (2023). Texnika ixtisosliklari mutaxassislik masalalarini yechishda C++ visual dasturlash tilida klasslardan foydalanish tahlili. *Electron Library Karshi EEI*, *1*(01). Retrieved from https://ojs.qmii.uz/index.php/el/article/view/272
15. ERGASHEV, N. THE ANALYSIS OF THE USE OF CLASSES IN C++ VISUAL PROGRAMMING IN SOLVING THE SPECIALTY ISSUES OF TECHNICAL SPECIALTIES. *http://science. nuu. uz/uzmu. php*.
16. Ergashev, N. (2023). Bulutli texnologıyalarda mavjud tahdidlar, ularga qarshi kurashish mexanizmları va metodlari. *Electron Library Karshi EEI*, *1*(01). Retrieved from https://ojs.qmii.uz/index.php/el/article/view/273