

**SECTION 2. Applied mathematics. Mathematical modeling.**

## THE SEARCH FOR THE OPTIMAL SUBSPACE OF RANDOM VARIABLES

**Abstract:** The algorithm of the search for the optimal subspace of random variables is described. The evaluation criterion for the conditions of complex systems performance is given. The presented criterion can be used for complex processes identification and the optimization of conditions of complex production systems performance.

**Key words:** Automated, system, subspace, processes, random variables.

**Language:** English

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Choosing the borders of studied factors it is necessary to generate a many-dimensional technological space, which complies with the optimal technology. After the choice of the primary space, the procedure of its borders alteration is carried out. The values of borders shifts for each factor is largely determined by the change degree of the criterion Q at various details of permissible range of these factors. The given subspace increasing or compressing and displacing within the technological space, «comes to a halt» when it reaches the largest observation of the criterion Q.

In the presence of large samples obtained by means of the computerized data gathering system, such a technique allows to make the better choice of the optimal technology. It allows to trace possible changes of the product profile. After formation of the data gathering system with new values technological parameters constantly received, the automatic account of product changes will be carried out with a slight delay. And each time under the circumstances there will be defined the better technology in terms of required properties.

The suggested borders shift procedures are very difficult to implement for all the factors of a multi-stage technology. If there are many units and processing stages then it is necessary to conduct the procedures of optimal borders choice for individual

units. If the search begins with the first unit then the finding optimal ranges of its factors changes as a rule turn out to be narrower than the range of sample changes.

The procedures of the optimal borders search for process stages and units may be eventually carried out in several variants.

- **variant 1:** a sequential search of the optimal borders from the first unit to the last one with the factors range «compression» because of the reduction of the studied sample size since the optimal ranges are not equal to the total range of factors changes;
- **variant 2:** the reverse direction of the optimal borders search (from the last unit to the first one);
- **variant 3:** enumeration of all possible search combinations of the optimal units technology. In this case each unit can be investigated as the first, the second, ..., the last one;
- **variant 4:** a simultaneous choice for all the factors of the multistage technology (laborious one);
- **variant 5:** the search of the optimal ranges for each unit excluding others. Then the matching of the optimal ranges is implemented, the finding multi-stage technology is compared with other alternatives. After this, the optimal technology of the production of the required quality is defined.

As an example, we shall consider the search procedure of optimal borders for three process stage having several operating conditions.

The sample volume is 2499 experiments. Operating conditions of each process stage are encoded by a pair combinations of characters «0, 1, 2». Many criteria consider only experiments  $t_{\gamma}^+/\mathcal{E}^*$  determining the frequency of obtaining of required properties as follows:  $\frac{(t_{\gamma}^+/\mathcal{E}^*)_R}{N(\mathcal{E}^*)}$ , where  $N(\mathcal{E}^*)$  is the volume of the lot implemented with a technology  $\mathcal{E}^*$ .

However choosing optimal technologies it is necessary to take into account the layout of experiments in the subset  $t^-$ . It can be done by

means of weighting coefficient and included in criteria (1):

$$K = \frac{(t_{\gamma}^+/\mathcal{E}^*)_R}{N(\mathcal{E}^*)} + \sum_{l=0}^{R-1} \left(\frac{\alpha_l l}{R}\right) * \frac{(t_{\gamma}^-/\mathcal{E}^*)_l}{N(\mathcal{E}^*)} \quad (1)$$

where  $\alpha_l$  is the coefficient increasing or weakening the influence of the points not included in the subset  $t_{\gamma}^+$  on the criterion ( $\alpha < 1$ ), R is the number of quality coefficients.

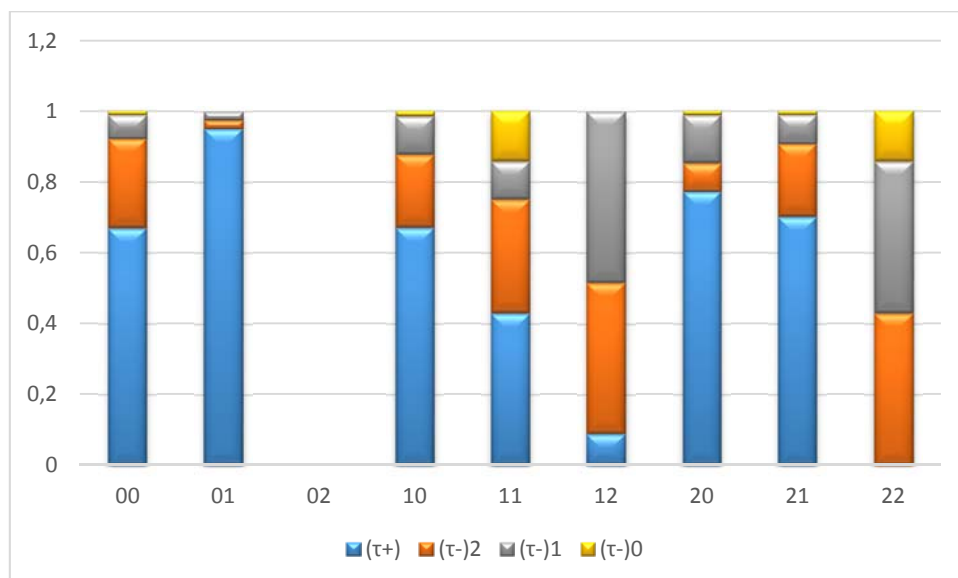
The example of the implementation of the optimal borders search procedure at the first process stage is presented in (table 1).

**Table 1**  
 The example of the implementation of the optimal borders search procedure at the first process stage.

Condition	$(\tau_{\gamma}^-/\mathcal{E}^*)_0$	$(\tau_{\gamma}^-/\mathcal{E}^*)_1$	$(\tau_{\gamma}^-/\mathcal{E}^*)_2$	$(\tau_{\gamma}^+/\mathcal{E}^*)$	$N(\mathcal{E}^+)$	K
$\mathcal{E}_{00}^+$	9	55	207	547	818	0,859821
$\mathcal{E}_{01}^+$	0	1	1	39	41	0,97561
$\mathcal{E}_{02}^+$	0	0	0	0	0	0
$\mathcal{E}_{10}^+$	20	143	272	884	1319	0,843821
$\mathcal{E}_{11}^+$	4	3	9	12	28	0,678571
$\mathcal{E}_{12}^+$	0	49	43	9	101	0,534653
$\mathcal{E}_{20}^+$	1	12	7	68	88	0,871212
$\mathcal{E}_{21}^+$	1	8	20	68	97	0,865979
$\mathcal{E}_{22}^+$	1	3	3	0	7	0,428571

As can be seen from the Table 1 the better operating condition at the first process stage is the condition  $\mathcal{E}_{01}^+$  that has the largest value of the criterion.

The percentage ratio of experiments from subsets  $t_{\gamma}^+$  and  $t_{\gamma}^-$  to the volume of the lot is presented in (diagram 1).



**Diagram 1 - The percentage ratio of experiments from subsets  $t_{\gamma}^+$  and  $t_{\gamma}^-$  to the volume of the lot.**

Impact Factor ISRA (India) = 1.344  
 Impact Factor ISI (Dubai, UAE) = 0.829  
 based on International Citation Report (ICR)  
 Impact Factor GIF (Australia) = 0.356

Impact Factor JIF = 1.500  
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 Impact Factor PIIH (Russia) = 0.179

On the ground of the chosen better operating condition on the first unit the optimal borders choice procedure is carried out sequentially for the two remaining units. The value of the criterion of the

operating conditions quality on the second unit are shown in (table 2).

The final result of the optimal borders sequential search procedure for the three process stages are shown in (table 3).

Table 2

The value of the criterion of the operating conditions quality on the second unit.

Condition	$(\tau_{\gamma}^-/\Xi^*)_0$	$(\tau_{\gamma}^-/\Xi^*)_1$	$(\tau_{\gamma}^-/\Xi^*)_2$	$(\tau_{\gamma}^+/\Xi^*)$	$N(\Xi^+)$	K
$\Xi_{0100}^+$	0	15	23	122	160	0,889583
$\Xi_{0101}^+$	1	6	6	28	41	0,829268
$\Xi_{0102}^+$	1	2	1	6	10	0,733333
$\Xi_{0110}^+$	6	29	105	281	421	0,85669
$\Xi_{0111}^+$	6	50	87	269	412	0,834142
$\Xi_{0112}^+$	1	6	5	52	64	0,895833
$\Xi_{0120}^+$	1	11	33	61	106	0,81761
$\Xi_{0121}^+$	4	19	11	57	91	0,776557
$\Xi_{0122}^+$	0	5	1	8	14	0,738095

Table 3

The final result of the optimal borders sequential search procedure for the three process stages.

Condition	$(\tau_{\gamma}^-/\Xi^*)_0$	$(\tau_{\gamma}^-/\Xi^*)_1$	$(\tau_{\gamma}^-/\Xi^*)_2$	$(\tau_{\gamma}^+/\Xi^*)$	$N(\Xi^+)$	K
$\Xi_{011200}^+$	0	1	4	1	6	0,542143
$\Xi_{011201}^+$	2	5	39	70	116	0,841954
$\Xi_{011202}^+$	0	0	1	8	9	0,962963
$\Xi_{011210}^+$	0	2	2	15	19	0,894737
$\Xi_{011211}^+$	0	2	9	54	65	0,933333
$\Xi_{011212}^+$	0	0	3	11	14	0,928571
$\Xi_{011220}^+$	0	0	0	0	0	0
$\Xi_{011221}^+$	3	2	6	1	12	0,472222
$\Xi_{011222}^+$	0	0	2	10	12	0,944444

It is worth mentioning that with a simultaneous search for several process stages the size of the required optimal space often turns out to be larger.

The finding value of properties with different approaches proves to be similar though.

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