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Criterion For Assessing The Effectiveness of Functioning of Complex Systems Based on The Use The Amount of Information

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Abstract

To select the optimal technology and product quality evaluation criteria need to be developed, which will link technology and the output properties, given the number of products when comparing the various parties (or technological conditions), consider all single indicators of quality in the complex, as well as to determine the quantitative and qualitative ratio of levels properties for different technologies .

Keywords: complex, processing, optimal technology, information, Criterion.

Frontier of factors technology make technological subset Ξ^*, serve turn technology Ξ [3,4]. Respectively technological subset that doesn't meet the requirements $\bar{\Xi} = \Xi \setminus \Xi^*$.Two disjoints subsets Ξ^* и $\bar{\Xi}$ and form a complete technological space Ξ - a multi-dimensional Euclidean space. Similarly, you can select a subset of output properties τ_γ^+, meets the requirements of the standards. Hence there are two possible outcomes: entering in the regulated subspace output properties τ_γ^+ (let us set this event τ_γ^+ / Ξ^*), and in the subspace that goes beyond the standards τ_γ^- $\tau_\gamma^+ / \bar{\Xi}$. At that the probability $P(\Xi^*) = P(\tau_\gamma^+ / \Xi^*) + P(\tau_\gamma^- / \Xi^*)$ .Event τ_γ^+ / Ξ^* , $\tau_\gamma^+ / \bar{\Xi}$, τ_γ^- / Ξ^* , $\tau_\gamma^- / \bar{\Xi}$ make a complete group of events: $P(\tau_\gamma^+ / \Xi^*) + P(\tau_\gamma^+ / \bar{\Xi}) + P(\tau_\gamma^- / \Xi^*) + P(\tau_\gamma^- / \bar{\Xi}) = 1.$

To carry out the comparative evaluation of alternatives and choose the best have to formulate criteria of optimality. The task to be solved is the choice of this technology,

for which the probability $P\ \tau_\gamma^+ / \Xi^*$ will seek to the probability $P\ \tau_\gamma^+$. That is, you need to choose the technology (such frontier technological factors), implementation of which will allow with the maximum probability of getting the output parameters to meet the requirements of the standard. Then, in turn, $P\ \tau_\gamma^+ \to 1$. The event τ_γ^- / Ξ^* is highly undesirable, since doesn't provide to take a standard regulated properties.(Можно еще сказать doesn't provide a standard regulated properties, or [doesn't provide to regulated standard's properties]) Hence necessary, for(или возможно that) $P\ \tau_\gamma^- / \Xi^* \to 0$. View of the objective function $Q\ Z \to \max$, where Z – vector parameters to be optimized: $Z = \{\Xi^*,\ \tau_\gamma^+ / \Xi^*\ ,\ \tau_\gamma^+ / \bar{\Xi}\ ,\ \tau_\gamma^- / \Xi^*\ ,\ \tau_\gamma^- / \bar{\Xi}\ \}$.

To solve the problem of discrete optimization, you can use the principles of information theory. As a criterion of evaluation technology uses a measure of the amount of information [5]. To determine the amount of information about the final properties, contained in the technology, the entropy calculated technology H_Ξ, the final properties H_τ and joint properties $H_{\Xi\tau}$. Amount of Shannon information is determined by:

$$I = -P(\Xi^*)\ln P(\Xi^*) - P(\bar{\Xi})\ln P(\bar{\Xi}) - P(\tau_\gamma^+)\ln P(\tau_\gamma^+) -$$
$$-P(\tau_\gamma^-)\ln P(\tau_\gamma^-) + P(\tau_\gamma^+ / \Xi^*)\ln P(\tau_\gamma^+ / \Xi^*) + P(\tau_\gamma^- / \Xi^*)\ln P(\tau_\gamma^- / \Xi^*) +$$
$$+P(\tau_\gamma^+ / \bar{\Xi})\ln P(\tau_\gamma^+ / \bar{\Xi}) + P(\tau_\gamma^- / \bar{\Xi})\ln P(\tau_\gamma^- / \bar{\Xi}).$$

Analysis of the criterion I have shown that the approach chosen by the use of the Boltzmann entropy maximum value of I has a range that is not always the best from the technological point of view.

Study of the graph of the function $-p\ln\ p$ from *p* shows the presence of a maximum value of a function at a probability *p* ≈0.37. However, when $P\ \tau_\gamma^+ / \Xi^*$ close to zero or close to unity a value $P\ \tau_\gamma^+ / \Xi^*\ \ln P\ \tau_\gamma^+ / \Xi^*$ also tends to zero, and I increases. This can lead to choosing the wrong technology.

When the probability value $P\ \tau_\gamma^+ / \Xi^* > 0{,}37$ criterion meets the set requirements, when $P\ \tau_\gamma^+ / \Xi^* < 0{,}37$ leads to the opposite results. Component $-p\ln\ p$ in the formula the amount of information relating to the joint entropy increases with its 0 to the probability ≈ 0, 37, leads to increased component $H_{\Xi\tau}$ and reducing the amount of information I. It in such a way behaves component P, the

probability formed $P\ \tau_\gamma^+ / \Xi^*$. With increasing off $P\ \tau_\gamma^+ / \Xi^*$ *to 0, 37* the amount of information *I* will be decrease.

It is therefore advisable to replace this component Boltzmann entropy conditional entropy, introduced by Hartley: $H = -\ln\ p$.

This will ensure that increasing component $P\ \tau_\gamma^+ / \Xi^*$ the amount of information will increase.

In the next step to this component $\ln\ p$ necessary to select the gain α. You can as *a* indicate the proportion of the sample size, which should correspond to τ_γ^+ / Ξ^* .

Component for τ_γ^- / Ξ^* also varies according to the law $-p\ln\ p$. However, when passing the cutoff 0.37 by increasing *p* the component $P\ \tau_\gamma^- / \Xi^*\ \ln P\ \tau_\gamma^- / \Xi^*$ Begins to decline, therefore criterion *I* began to increase.

To avoid this, we introduce the penalty factor β and pass the critical point (with increasing $P\ \tau_\gamma^- / \Xi^*\ > 0{,}37$) replace component $P\ \tau_\gamma^- / \Xi^*\ \ln P\ \tau_\gamma^- / \Xi^*$ on component $\beta P\ \tau_\gamma^- / \Xi^*$.

Since the component τ_γ^- / Ξ^* is extremely undesirable, т the introduction of a penalty factor β can significantly increase the component; a probability formed $\beta P\ \tau_\gamma^- / \Xi^*$ and reduce the value of the criterion *I*.

So α *(α<1)* cannot compress select the area Ξ^*, and hence τ_γ^+ / Ξ^* to point (to a small size), and the criterion β *(β>1)* does not allow much to expand the test subspace Ξ^* due to the fact that this would lead to an increase in component τ_γ^- / Ξ^* and reduction criterion *I*.

Replace:

$$-P(\tau_\gamma^+ / \Xi^*)\ln P(\tau_\gamma^+ / \Xi^*) \to -\alpha \ln P(\tau_\gamma^+ / \Xi^*);$$

$$-P(\tau_\gamma^- / \Xi^*)\ln P(\tau_\gamma^- / \Xi^*) \to \beta P(\tau_\gamma^- / \Xi^*).$$

Obtain a modified criterion [1,6,7]:

$$Q_m = -P(\Xi^*)\ln P(\Xi^*) - (1-P(\Xi^*))\ln(1-P(\Xi^*)) - P(\tau_\gamma^+)\ln P(\tau_\gamma^+) -$$
$$-(1-P(\tau_\gamma^+))\ln(1-P(\tau_\gamma^+)) + \alpha \ln P(\tau_\gamma^+ / \Xi^*) - \beta(P(\Xi^*) - P(\tau_\gamma^+ / \Xi^*)) +$$
$$+(P(\tau_\gamma^+) - P(\tau_\gamma^+ / \Xi^*))\ln(P(\tau_\gamma^+) - P(\tau_\gamma^+ / \Xi^*)) +$$
$$+(1-P(\Xi^*) - P(\tau_\gamma^+) + P(\tau_\gamma^+ / \Xi^*))\ln(1-P(\Xi^*) - P(\tau_\gamma^+) + P(\tau_\gamma^+ / \Xi^*)).$$

Theorem

If two independent random variables Ξ and τ have two states, and the amount of information determined by the entropy of the Boltzmann $I_{\Xi\tau} = H_\Xi + H_\tau - H_{\Xi\tau}$, then the replacement part $P\ \tau_\gamma^+ / \Xi^*$ Boltzmann entropy $H_{\Xi\tau}$ on the entropy component Hartley, modified criterion has no extremum and increases with increasing $P\ \tau_\gamma^+ / \Xi^*$.

Hence a modified criterion has not extremum increases with increasing $P(\tau_\gamma^+ / \Xi^*)$.

Since the task of selecting the optimal technology within the permitted range of variation of factors can be identified segments for which the probability of obtaining quality products is the maximum $P\ \tau_\gamma^+ / \Xi^* \to \max$. But at the same time to develop criteria are not considered capable of compressing segments to very narrow limits, in particular, to the complete elimination of component $P\ \tau_\gamma^- / \Xi^*$. This is because increasing the probability of hitting the partition detail in each of the segments $P\ \Xi^*$, and hence $P\ \tau_\gamma^+ / \Xi^*$ decreases, that takes into account the criteria used, and further compression of areas hit factors of the criterion Q will decline.

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