METHODS OF BUILD-DOWN VARIANCE OF THE SIMULATION MODEL

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The new method of build-down of a variance of the simulated random quantities, based on application of the filter of Kolmogorov is suggested.

The solution of some operating problems at the factories of electro power systems (EPS) assumes selection of the version responding presented increased requirements. Thus, a natural condition is the minimum risk of an erratic solution. With a special urgency the problem of objectivity of a solution originates by selection of the versions, one of principal demands to which is reliability of activity of the particular equipment, systems or of the equipments, which in the further we shall agree to name in plants EPS. The fundamental obstruction for an error-free solution is decrease of number of data about failures of the same type plants in process of reflecting "individuality". Aftereffects of erratic solutions directly mirrored in magnifying of working costs.

The simplest mode of selection of version is the intuitive approach. However would be erratic to assume, that the intuitive solution, on the average, justifies itself. The awkwardness and complexity of compared versions is more, the ability of technicians to cover all aspects of a problem, including the information describing reliability of versions, - less.

Among mathematical modes of selection of version, the greatest propagation received with the methods based on matching of boundary values of a confidence interval. Moreover, absolutely fairly it supposed that if confidence intervals at the preset confidence coefficient not combined, difference of versions could accept with the certain reliance. The analogous supposition could accept, if a spacing of variation of a difference of indexes on which versions compared, does not switch on a zero value.

Analytically to calculate boundary values of a confidence interval it is possible seldom enough since the law of allocation of random quantities, as a rule, it is unknown. Alternatively, for a quantitative assessment of a confidence interval it is necessary to do such suppositions which reliability is quite often doubtful and it yet all. At small number of data about reliability of particular plant confidence intervals appear so greater, that are necessarily combined on a scale of measurement and the answer is in most cases univalent: the information has not enough for an adoption of a decision.

One of the most perspective directions at a solution of similar problems is development of simulation models. Conducting "experiments" on a simulation model, we receive a range and we can evaluate a spacing of their variation which for simplification we shall name accuracy of a simulation model (ASM). If compared indexes represent an average arithmetical value of random quantities (for example, average down time in emergency repair) ASM matches to a confidence interval. If probability rates (for example, an operational readiness coefficient) are simulated – that ASM matches to a tolerant spacing. ASM depends on a mode of simulation analysis of random numbers and structure of a simulation model. In the present paper, we shall survey dependence ASM on a mode of simulation analysis of random quantities.

To this problem known in theory, simulation modeling as modes of build-down of a variance, are devoted numerous probing. Series of approved methods of build-down of a variance offered. Positive takes of sharing of some methods known. In [1], in particular, it noted about positive takes of sharing of a method of common random numbers and a method of complementary values. In [2] it noted that boosting ASM for this combination reached more often not at matching versions, and at determination of indexes of particular version. Difficulties of shaping of univalent references caused by their essential dependence on a type of a solved problem and, in particular, availability positive (or negative) correlations between simulated values. The special notice at probing given simulation models of queuing systems, and compared indexes represent an average arithmetical of continuous random quantities. This problem has been surveyed and in [3].

We survey a little bit other model requiring boosting ASM. Mean a solved problem – comparison of the averaged indexes of reliability (AIR) with indexes of individual reliability (IIR). Such comparison simplifies selection most (least) safe of the same type plants and by that a solution of particular operating problems. For example, comparison AIR and IIR power-generating units of the power stations, separate turbines and boiler units allows to secrete plants which reliability is more (less) AIR.

In [4] authors the criterion of the supervision of imposing appearance of sampling (IAS) Δ_m, has been offered, allowing to evaluate divergence AIR and IIR. Errors of the first and second stem, risk of an erratic solution determined. By comparison, AIR and IIR three outcomes possible:

– separation of a data set to the preset indication is expedient, i.e. assessment AIR and IIR differ was nonrandom

– separation of a data set to the preset indication is illogical, i.e. assessment AIR and IIR can differ random

– it is not enough data of sampling for the certain inference, the data striping is illogical

These outcomes largely determined by spread of implementation of the same type AIR and IIR. Therefore and for Δ_m, build-down of probability of an inference about a failure of the information also is actual.

First it was necessary to evaluate a degree of build-down of an assessment of a variance $D^*(\Delta_m)$, is more exact than an average quadratic deflection $\sigma^*(\Delta_m)$, at usage of the known simulation methods of random quantities approved on other problems. To the greatest degree to approximate solved problems we indexes of reliability that also represent an average arithmetical random quantities surveyed.

Already first outcomes of simulation analysis at number of iterations N_i=500 indexes, that:

– outcomes of accounts of the implementation Δ_m having the discrete character, are largely determined by number of random quantities of sampling (n) duration of estates (τ). The n it is less, the $\sigma^*(\Delta_m)$ it appears greater; that completely matches to physical nature of an assessment Δ_m;

– the essential spread as means $\Delta_{m,cp}$ is watched, and $\sigma^*(\Delta_m)$. In these conditions comparison $\sigma^*(\Delta_m)$ became aberrant and required junction of analysis of variation $\sigma^*(\Delta_m)$ for analysis of variation of a coefficient of variation $k^*(\Delta_m) = \sigma^*(\Delta_m)/\Delta_{m,av}$;

– as one would expect application of a method of common random numbers, eliminating one of radiant of spread of implementation (Δ_m), has ensured appreciable build-down $k^*(\Delta_m)$;

– application of a method of complementary random quantities together with a method of common random numbers practically has not rendered appreciable build-down on the reached value $k^*(\Delta_m)$.

– appreciable build-down $\sigma^*(\Delta_m)$ has been reached by application recommended by authors a method, which short is reduced to the supervision Kolmogorov's by criterion of correspondence simulated by a program mode (RAND (x)) random numbers of sampling to the uniform law in the interval [0,1]. With the purposes of simplification in the further, this method we shall name Kolmogorov's filter.

– at small value of number of implementation of sampling $\{\tau\}_n$ the parity $k^*(\Delta_m) > 0{,}3$ that bears to some asymmetry of allocation $F(\Delta_m)$ is watched.

Application of the filter of Kolmogorov especially effectively at small value n and generally not only diminishes $\sigma^*(\Delta_m)$, i.e. spread of deflections $F^*(\Delta_m)$ from $F(\Delta_m)$, but also spread of value of evolution of risk of an erratic solution $\gamma(\Delta_m)$ and a best value of criterion IAS $(\Delta_{m,opt})$.

In the illustrative purposes in table 1 some outcomes of accounts of distribution parameters for two similar criteria are reduced: IAS (Δ_m) and Smirnov ($D_{m,n}$), of some value of number of implementation of sampling (n) and number of a data set, peer 19.

Given tables 1 evidently confirm the simulation analysis of random numbers noted above a singularity and, in particular, intuitively a clear inference about build-down of effect of application of the filter of Kolmogorov with body height of number of implementation of sampling and immutability of conclusions at magnifying of number of iterations N_i with 500 up to 1000.

Table 1

Comparative assessment of methods of build-down a variance at imitative simulation analysis of statisticians Δ_m and $D_{m,n}$

Simulation method of random numbers	Type statisticians	Number of random quantities of sampling: 3			5			15		
		Average value	Av.quadratic deflection	Quotient variations	Average value	Av. quadratic deflection	Quotient variations	Average Value	Av. quadratic deflection	Quotient variations
The standard program RAND (X)	Δ_m	0,293 0,319	0,132 0,141	0,452 0,442	0,26 0,26* 0,25*	0,110 0,107* 0,107*	0,423 0,412* 0,427*	0,14 0,14	0,053 0,051	0,37 0,36
	$D_{m,n}$	0,472 0,478	0,143 0,148	0,303 0,310	0,391 0,394 0,397	0,130 0,125* 0,124*	0,330 0,318 0,312	0,28 0,27	0,089 0,083	0,32 0,31
Method of complementary random quantities	Δ_m	0,312	0,143	0,458	0,24	0,10	0,43	0,14	0,050	0,36
	$D_{m,n}$	0,478	0,140	0,294	0,38	0,12	0,31	0,28	0,085	0,31
Kolmogorov's filter	Δ_m	0,256	0,903	0,353	0,18 0,182* 0,81	0,061 0,058* 0,059*	0,34 0,348* 0,326*	0,13	0,039	0,31
	$D_{m,n}$	0,378	0,857	0,227	0,28 0,277 0,275	0,059 0,058* 0,059*	0,021 0,021* 0,021*	0,25	0,068	0,27

Remarks: * matches $N_{i=1000}$; in remaining events N_i = 500.

On fig. 1 the graphical case history of allocations $F^*(\Delta_m)$ for the random numbers a thinning oscillated by a program mode $F_1(\Delta_m)$, a method of complementary values $F_2(\Delta_m)$ and generated by the supervision of correspondence a thinning Kolmogorov's $F_3^*(\Delta_m)$ to criterion is reduced

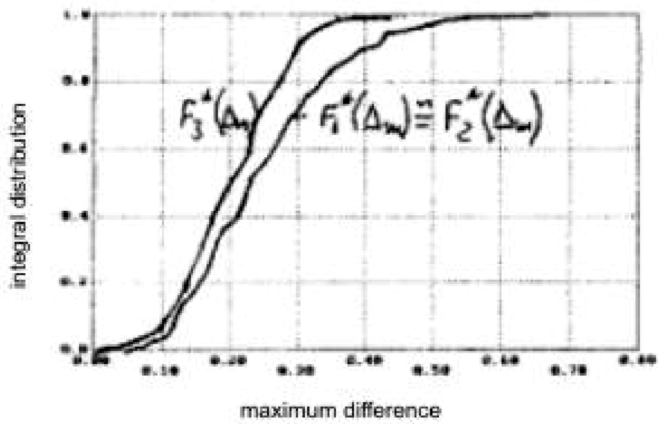

Fig.1. A graphical case history of allocation $F^*(\Delta_m)$ depending on a simulation method of implementation a thinning of random quantities

As follows from fig.1, allocations $F_1^*(\Delta_m)$ and $F_2^*(\Delta_m)$ are practically indiscernible (complementary random numbers have not reduced a variance) and is essential differ from the allocation $F_3^*(\Delta_m)$ having minimum value $\sigma^*(\Delta_m)$ from compared methods.

In table 2 the outcome of comparison of allocations $F^*(\Delta_m)$ displayed and $F^*(D_{m,n})$ at four, noted in table 2, simulation methods a thinning of random quantities.

As follows from table 2:

- as $K^*[D_{m,n} - \Delta_m] >> 0{,}3$, comparison of spread of implementation Δ_m should be conducted on $\sigma^*[D_{m,n} - \Delta_m]$;
- application of the filter of Kolmogorov reduces value $M^*[D_{m,n} - \Delta_m]$. This effect speaks removal unpreventable a thinning of the random quantities causing "surges" of possible divergences $D_{m,n}$ and Δ_m;
- the greatest effect for build-down $\sigma^*[D_{m,n}\ u\ \Delta_m]$ is reached by application of a method of the common random quantities which have been last through the filter of Kolmogorov.

On fig. 2 are displayed to regularity of variation of statisticians $D_{m,n}$ and (Δ_m) for simulation methods differing a thinning (fig. 2a) and a simulation method of common random quantities of the past through Kolmogorov's filter (fig. 2б) for 40 iterations.

Table 2

Comparative assessment of methods of build-down of a variance of a difference of statisticians $D_{m,n}$ and Δ_m at n=5 and M=19

	Methods of shaping of random quantities	$M^*[D_{m,n} - \Delta_m]$	$\sigma^*[D_{m,n} - \Delta_m]$	$K^*[D_{m,n} - \Delta_m]$
1	Simulation analysis differing a thinning	0,159	0,161	1,02
2	Simulation analysis differing a thinning, the past through Kolmogorov's filter	0,102	0,0836	0,818
3	Simulation analysis of common random quantities	0,141	0,0806	0,572
4	Simulation analysis of the common random quantities which have been last through the filter of Kolmogorov	0,097	0,060	0,62

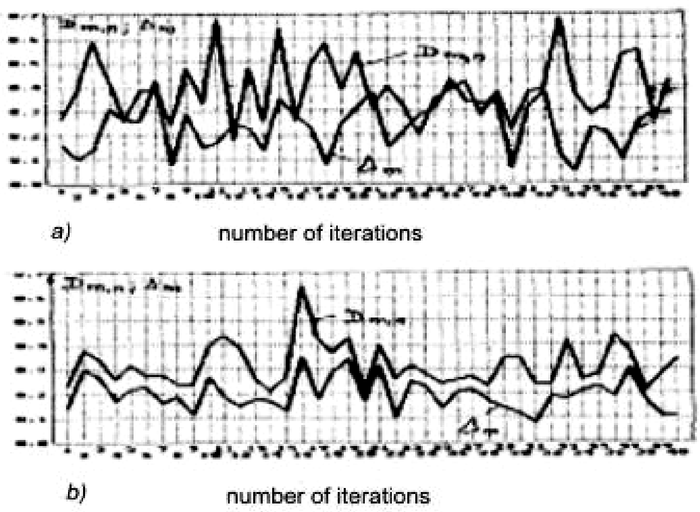

Fig. 2. Regularity of variation of implementation of statisticians $D_{m,n}$ and Δ_m.

Data fig. 2б. Evidently, bear to decrease of surges of a divergence of a statistician on matching from fig 2a.

On fig. 3a and 3б parity $D_{m,\,n}$ and Δ_m, in each iteration for the same simulation methods are displayed. These graphs evidently illustrate noted in table2 regularity, and explain reasons of an ineffectiveness of a method of complementary random quantities.

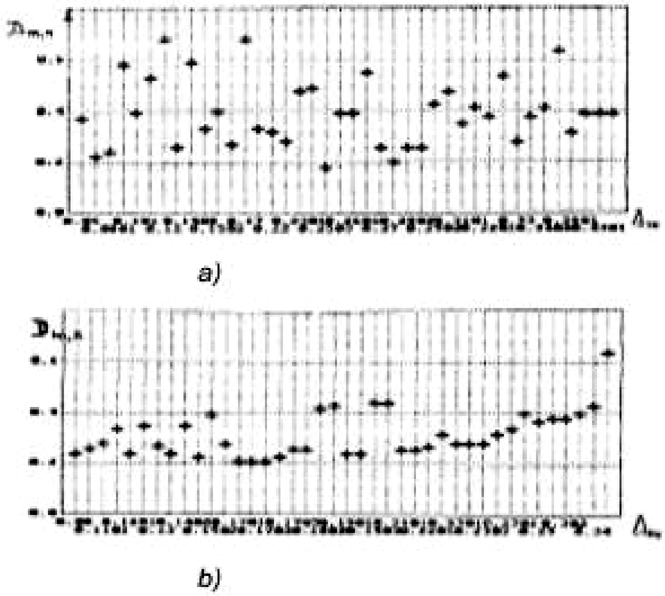

Fig.3. The Correlative field of intercoupling of statisticians $D_{m,n}$ and Δ_m at *a* – simulation analysis differing a thinning; *b*– simulation analysis common a thinning, the past through Kolmogorov's filter.

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İMİTASİYA MODELİNİN DİSPERSİYASININ AZALDILMASI ÜSULU

Kalmaqorov filtrinin tətbiqinə əsaslanan, yeni modelləşdirilmiş təsadüfi kəmiyyətlərin dispersiyasının azaldılması üsulu təklif olunmuşdur.

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МЕТОДЫ СНИЖЕНИЯ ДИСПЕРСИИ ИМИТАЦИОННОЙ МОДЕЛИ

Предложен новый метод снижения дисперсии моделируемых случайных величин, основанный на применении фильтра Колмогорова.

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