METHOD AND ALGORITHM OF THE CHOICE OPTIMUM NUMBER ATTRIBUTES DESCRIBING RELIABILITY OF THE EQUIPMENT OF ELECTRO INSTALLATIONS

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ABSTRACT

Estimation of parameters of individual reliability demands to estimate expediency of classification of all population of statistical data on the set versions of attributes. The method and algorithm optimum number of attributes classification of data is developed. Application allows calculate optimum on accuracy of an estimation of parameters of individual reliability, to reveal significant versions of attributes, to pass at the account of reliability of the concrete equipment with qualitative to a quantitative level

I. INSTRUCTION

Objective estimation of reliability of the concrete equipment of electro installations demands attraction of data about the attributes describing their individuality and reliability of work. A source of these data are the passport of the equipment, data on conditions of operation, reports of preventive tests, data on restoration of deterioration at carrying out of emergency and scheduled repairs. Thus, the knowledge of features of functioning of the equipment, deterioration of its units, an operational experience and intuition of the researcher has great value. Today probably, it is not necessary to approve, that such calculations with such volume and a variety of data can be spent only on the basis the automated information systems.

Each attribute is characterized not less than two versions of attributes (VA). For set VA the concrete equipment to make sample of data does not represent any difficulties. Difficulties arise when we pass to an estimation of parameters of reliability. It is known, that at such classification data for calculation of parameters of reliability or absolutely absent or insufficient for calculation of their average and guaranteed values. For this reason in practice only average values of parameters of reliability are calculated, in other words, the attributes noted above simply are not considered. Thus, the opportunity of the objective decision of many operational problems connected with the organization of maintenance service and repair of the equipment excluded. It is obvious, that subjective decisions it is far not always and not for all problems correct. To overcome noted difficulties of an estimation of parameters of individual reliability it is possible by the account of the importance of the set versions of attributes. Classification to insignificant attributes is inexpedient. In practice of an estimation of parameters of reliability of the equipment calculated for one, less often – to two VA. As examples, estimations of parameters of reliability for the equipment of a various class of a voltage, type, and an installation site can serve, etc.

However, at such formal classification there are unresolved following questions:

- What reliability of the assumption of not casual divergence of the average estimations of parameters of reliability calculated on all population of statistical data (Π^*_Σ) and the estimations calculated on sample of data ($\Pi^*_{v,i,j}$) for everyone VA, where i–a serial number of attributes, and j– serial number VA;
- What reliability of the assumption of not casual divergence of estimations on versions i-го an attribute, for example $\Pi^*_{v,i,j}$ and $\Pi^*_{v,i,(j+1)}$.

Such the sort of a problem should be solved in conditions of high uncertainty when practically it is not known about multivariate data, including about a kind of the law of distribution of random variables, and any assumptions (for example, about normal the law of distribution and independence VA) put new questions, in particular, about objectivity and risks of the erroneous decision [1]. Dependence of statistical data on set VA demands transition from concept «general population » to concept «final population of multivariate statistical data», and, hence, to transition to corresponding methods of the statistical analysis.

Development of methods and algorithms of a choice of the optimum number VA, describing reliability of the equipment of electro installations, allows calculating authentic estimations of parameters of individual reliability and to lower expenses for carrying out of their maintenance service and repair.

Statement of a problem.

Methods and algorithms of a choice of optimum number of attributes depend, first, on parameters of reliability and type of a scale of measurement of an attribute. Formulas of an estimation of parameters of reliability on statistical data of operation of the equipment known and presented by two versions:

1. The parameters of reliability calculated as average arithmetic random variables. For example, average duration of idle time in emergency repair, average duration of a finding in a reserve, etc.
2. The parameters of reliability calculated as probability of occurrence of event. For example, probability of refusal, specific number of refusals, probability of overlapping of conditions, etc.

In practice of a version of many attributes are fixed. For example, an installation site, a kind of the equipment, area of storm activity, etc. Only at a small part from these attributes number of versions equally to two.

VA with a quantitative scale of measurement set heuristically in the form of intervals of data. Hit of a random variable, for example, in j-th an interval testifies to display j-oh VA.

In the present article, we shall consider a method and algorithm of a choice of optimum number VA for the parameters of reliability concerning the first kind, i.e. calculated as average arithmetic random variables and we shall estimate them for attributes with a nominal scale of measurement.

Method and algorithm for a nominal scale of measurement attribute. For simplification of a statement, specify a solved problem. Let it is known m realizations of duration of idle time in emergency repair (τ_a) the instruction of date of occurrence of refusal. It is required to estimate laws of change of average duration of idle time in emergency repair on months. Thus, realizations τ_a are characterized by twelve VA. For the accepted conditions of a problem, calculations spend in following sequence:

1. Average arithmetic value of all realizations is calculated τ_a under the formula $M^*_\Sigma(\tau_a) = m^{-1}\sum_{j=1}^{m}\tau_j$
2. Samples of random variables are formed τ_a, concerning each of set VA. For example, at refusals in January (the first VA) sample looks like $\{\tau_a\}_1$;
3. Calculate average arithmetic value of random variables of each sample;
4. Random variables of each sample are placed in ascending order, fixed their minimal $\tau_{min,i}$ and the maximal value $\tau_{max,i}$ with i=1, n statistical functions of distribution (s.f.d. also are formed.) $F^*_{v,i}(\tau_a)$ with i=1,n;
5. Importance VA it is coordinated with representative samples concerning final population of multivariate data, i.e. a file $\{\tau_a\}_\Sigma$. At the first analysis stage, the realizations $M^*_{v,i}(\tau_a)$ calculated according to sample, we divide into three groups. The first group includes n1 the estimations $M^*_v(\tau_a)$ casually differing from $M^*_\Sigma(\tau_a)$, the second group includes n2 estimations $M^*_v(\tau_a)$ which not casually exceed $M^*_\Sigma(\tau_a)$, and the third group includes n3 estimations $M^*_v(\tau_a)$ which

it is not casual less $M^*_\Sigma(\tau_a)$. The second and third groups consist from significant VA, and the first – from insignificant. To the second group of estimations $M^*_v(\tau_a)$ we carry VA, for which $M^*_\Sigma(\tau_a)<\tau_{min,i}$ also does not concern, if $M^*_\Sigma(\tau_a)>M^*_{v,i}(\tau_a)$. If $\tau_{min,i}<M^*_\Sigma(\tau_a)<M^*_{v,i}(\tau_a)$, $M^*_\Sigma(\tau_a)$ it is compared with quantile s.f.d. $F^*[M^{**}_{v,i}(\tau_a)]$, corresponding probability β=0,05. S.f.d. $F^*[M^{**}_{v,i}(\tau_a)]$ pays off as follows:

On s.f.d. $F^*_{v,i}(\tau_a)$ By the stated [2] method it is modeled m_i realizations of a random variable τ_a, where m_i number of realizations of sample for considered VA;
Average arithmetic value of these realizations $M^{**}_{v,i}(\tau_a)$ is calculated;
Calculations on i.5.1. and i.5.2. repeat N time;
Is under construction s.f.d. $F^*[M^{**}_{v,i}(\tau_a)]$ and on realization $M^{**}_{v,i}(\tau_a)$ with serial number Nβ It is defined квантиль the distribution $M^{**}_{v,i}(\tau_a)$ corresponding probability β.

Experience of calculations shows, that the number of realizations N=100 is quite enough for classification VA on the groups noted above. Performance of a condition $M^*_\Sigma(\tau_a)<M^{**}_{v,i}(\tau_a)$ with a significance value β testifies to an accessory considered VA to the second group. Notice, that conditions $M^*_\Sigma(\tau_a)<\tau_{min,i}$ unequivocally $M^*_\Sigma(\tau_a)>M^*_{v,i}(\tau_a)$ testify that considered VA, accordingly, belongs and does not belong to second group VA. However these conditions concern to a kind necessary, but insufficient for judgment about an accessory of all VA to the first group. They are rather useful to decrease in time of calculation;

6. If VA do not concern to the second group, except for a case, when $\tau_{min,i}<M^*_\Sigma(\tau_a)<\underline{M^{**}_{v,i}}(\tau_a)$, this VA is checked on conformity to the third group. For what the condition is checked: $M^*_\Sigma(\tau_a)>\tau_{max,i}$. If this condition carried out, VA belongs to the third group. Otherwise the condition $M^*_\Sigma(\tau_a)<M^*_{v,i}(\tau_a)$ is checked. If the condition carried out, VA belongs to the first group. If $M^*_{v,i}(\tau_a)<M^*_\Sigma(\tau_a)<\tau_{max,i}$ it is entered into consideration quantile the distributions $F^*[M^*_{v,i}(\tau_a)]$, corresponding probability (1-β). If it quantile $\overline{M^{**}_{v,i}}(\tau_a)$ appears less, than $M^*_\Sigma(\tau_a)$ considered VA concerns to the third group, and otherwise – to the first;
7. Further pass to consideration next VA with constant conditions of check representative samples;
8. The first stage of calculation comes to the end by consideration of all VA;
9. If it will appear, that n1≤1 and (or) n2≤1 classification of a final data population on VA comes to the end. From n VA no more than to two VA there correspond the estimations $M^*_v(\tau_a)$ differing from $M^*_\Sigma(\tau_a)$;
10. Otherwise it is necessary to continue calculations and to establish character of a divergence of parameters of reliability concerning the second group and (or) to the third group. Considering, that methodology for the analysis of importance VA for the second and third groups are similar, we shall consider only a case, when n1> 1;
11. From final population of multivariate data $\{\tau_a\}_\Sigma$ spend sample of the realizations corresponding one of n1 VA of the second group. We shall designate set of realizations of this sample as $\{\tau_a\}_{\Sigma 1}$;
12. All the subsequent calculations it is spent in strict conformity with i.(1÷8) with that difference, that instead of $\{\tau_a\}_\Sigma$ it is analyzed $\{\tau_a\}_{\Sigma 1}$.

This stage of calculations allows increase number of significant attributes with 3 up to 7. Experience of calculations for statistical data of operation of the equipment of electro installations shows, that on it calculations, as a rule, come to the end

The block the scheme of algorithm of a choice of optimum number VA is resulted in figure 1 and supplements practical realization of a method for a nominal scale of measurement VA.

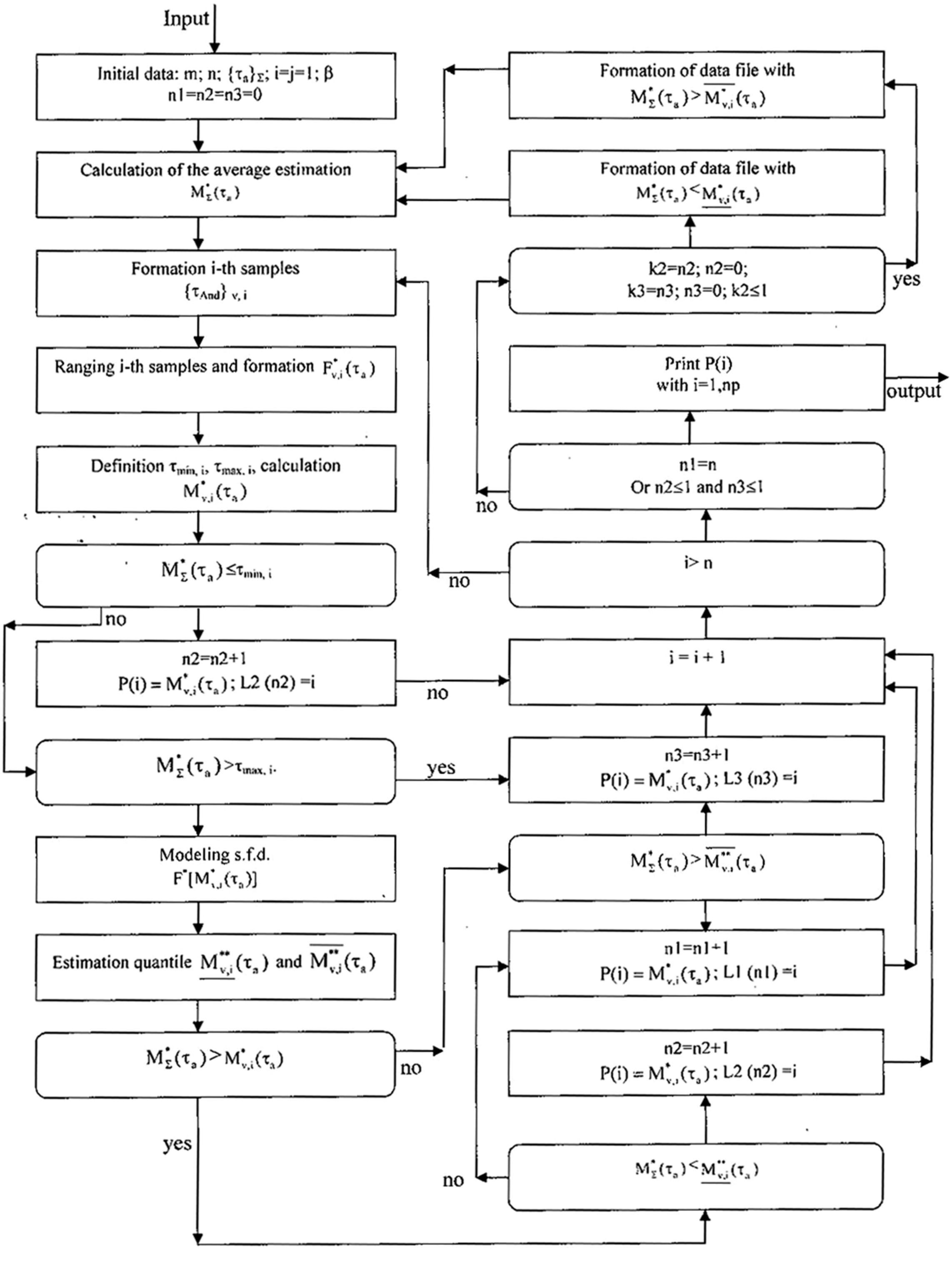

Fig.1. Algorithm of a choice of optimum number VA

Example of calculation. The illustration of calculations on the basis statistical data of operation is not always justified by the method stated above, as the true result and consequently, there is nothing to compare with results of calculations here is not always known, to estimate reliability. In these conditions, it is expedient to apply a method of the decision of "a return problem» according to which statistical data are modeled on in advance stipulated model, and results of calculation on these data should repeat structure of model.

In table 1 realizations of random variables are resulted τ For four VA with the set functions of distribution F(τ). Modeling of realizations was spent on the basis of random numbers ξ [2 tabl.9.1.] with are uniform distribution in an interval [0,1].

Table 1

Realization of random variables τ_a

N	Function of distribution of realizations for VA							
	τ=80ξ		τ=100 (ξ+0,5)		τ=50 (ξ+1,5)		τ=50 (ξ+3)	
	ξ	τ, c	ξ	τ, c	ξ	τ, c	ξ	τ, c
1	0,1009	8,1	0,1218	62,2	0,7942	114,7	0,9959	199,8
2	0,3754	30	0,6606	116,1	0,8868	119,3	0,6548	182,7
3	0,0842	6,7	0,3106	81,1			0,8012	190,1
4	0,9901	79,2	0,8526	135,3			0,7435	187,2
5			0,6357	113,6			0,6991	185,0
6			0,7379	123,8			0,0989	155,0
7			0,6234	112,3				
8			0,1180	61,8				

Given tables 1 allow to establish:

1. $M^*_\Sigma(\tau)=115.1$c.;
2. Boundary values of intervals of disorders of realizations of a random variable τ For considered four VA (models) ($\tau_{min} \div \tau_{max}$) are accordingly equal: (6,7÷79,2); (62,2÷135,3); (114,7÷119,3); and (155÷199,8);
3. Average values of each of four выборок $M^*_v(\tau)$ are accordingly equal: 31c., 100,8c., 117c., 183,1c.;
4. Comparison $M^*_\Sigma(\tau)$ to boundary values τ_{min} and τ_{max} shows:

4.1. The first VA for which $M^*_\Sigma(\tau)>\tau_{max,\,1}$, causes not casual divergence with $M^*_\Sigma(\tau)$;

4.2. For the second VA $\tau_{min}<M^*_\Sigma(\tau_a)<\tau_{max}$ and therefore $M^*_\Sigma(\tau_a)>M^*_{v,2}(\tau)$, it is required attraction of size $\overline{M^{**}_{v,2}}(\tau)$;

4.3. For the third VA also as well as at the second $\tau_{min,\,3}<M^*_\Sigma(\tau_a)<\tau_{max,\,3}$, but $M^*_\Sigma(\tau)<M^*_{v,3}(\tau)$ attraction of size $\underline{M^{**}_{v,3}}(\tau)$ also is required;

4.4. The fourth VA for which $M^*_\Sigma(\tau)<\tau_{min,\,4}$ causes not casual divergence $M^*_\Sigma(\tau)$ and $M^{**}_{v,4}(\tau)$;

5. Results of calculations $\overline{M^{**}_{v,i}}(\tau)$ and $\underline{M^{**}_{v,i}}(\tau)$ are resulted to table 2;

Table 2

Results of calculations of critical values of realizations $M^*_{v,i}(\tau_a)$

Parameter	Level the importance β	Conditional number VA (i)			
		1	2	3	4
$\underline{M^*_{v,4}}(\tau)$	0,05	11,5	84,4	116,2	171,8
$\overline{M^{**}_{v,4}}(\tau)$	0,95	61,8	118,2	119,1	193,6

6. As follows from table 2, $M^*_\Sigma(\tau) < \overline{M^{**}_{v,2}}(\tau)$, differently burning $M^*_\Sigma(\tau)$ and $M^*_{v,2}(\tau)$ differ casually, and $M^*_\Sigma(\tau) < \underline{M^{**}_{v,3}}(\tau)$ and therefore $M^*_\Sigma(\tau_a)$ and $M^*_{v,3}(\tau)$ differ not casually;
7. Results of calculations of an estimation of expediency of classification of statistical data on set VA it is resulted in table 3

Table 3

Results of classification of statistical data on VA

Number VA	Parameter	Numerical value	Significant VA
1	$M^*_{v,1}(\tau)$	31	Yes
2	$M^*_{v,2}(\tau)$	115,1	No
3	$M^*_{v,3}(\tau)$	117	Yes
4	$M^*_{v,4}(\tau)$	183,1	Yes
-	$M^*_\Sigma(\tau)$	115,1	-

CONCLUSIONS

1. Unreasonable classification of statistical data on set VA (for example, on a class of a voltage, type, an installation site, months of year, duration of operation and so forth) can lead to distortion of real values of parameters of reliability of the equipment of electro installations.
2. The method and algorithm of definition of optimum number VA on based on imitating modeling and the theory of check of statistical hypotheses is developed.
3. Application of this method allows to raise accuracy of estimations of parameters of reliability calculated as an average arithmetic random variables, to reveal significant VA, to raise efficiency of monitoring of reliability of the equipment of electro installations

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