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STUDY NONPARAMETRIC TEST SHIFT IN NDT TASKS

Abstract. A comparative analysis of the power of nonparametric tests comparing changes in samples of independent and autocorrelated random variables with different probability distribution. Investigated the performance criteria in the problem of comparing samples with different laws of probability distribution.

Keywords: sample measurement, test power, nonparametric shift.

Statement of the Problem

In problems of ultrasonic nondestructive testing facilities information about their condition found in samples of measurements, statistical regularities which are usually unknown. Change of statistical regularities is indicative of the changing state of the object. Assessment of change can be used in the control of the same objects and monitoring their condition during the operation, after prolonged storage, transportation, repair. Problem of detecting changes in the state of objects can be solved by comparing two samples of measurements with unknown probability distribution. Most often, the sample groups differ center and the magnitude of the scattering measurements (shift and scale terminology nonparametric statistics) [1]. In [1] considered the ten methods of using nonparametric shift for comparing two samples of random variables. This criteria Ken rank, Mann-Whitney-Wilcoxon, van der Waerden, median, Mosteller, Rosenbaum, Hagi, E-test. Criteria Mosteller and Rosenbaum are ineffective and are therefore not considered.

When comparing samples of erroneous measurements are two solutions: 1) at equality shifts samples of random variables taken the opposite decision (error first kind), 2) when comparing two samples with unequal shifts made wrong decisions about their equality (error second kind). These non-parametric tests can be used to shift the problems of nondestructive testing to detect elements with unknown random parameters measured with errors and various laws of probability distribution.

The purpose of research - assessment of probability of erroneous decisions and comparative analysis of the efficiency of nonparametric tests for different types of shear distribution laws of probability and correlation of random variables in problems of non-destructive testing.

Computational experiments

The paper discusses the criteria in the context of the shift that compared samples of random variables have the same scale.

Investigated samples of random variables with probability distribution: logistic, Laplace, Gauss. And correlated normal random variables. The length of the test sample and the number of independent experiments performed. Efficiency criterion is its ability to recognize the difference between the shifts studied samples. Computational experiments were performed as follows:

1. Two samples with the logistics (Laplace, normal) distribution with equal variances, the mean of one sample is fixed and equal to zero, and the second - varies from zero to one, with increments of 0.1.
2. Correlated normal random variables ($r=0$, $r=0.5$, $r=0.9$),also for one fixed mean and changing other, with the same pitch.
3. Samples with different laws of probability distribution (normal and logistics; normal and Laplace, logistic and Laplace) a fixed offset of one sample and changing - another.

Analysis of the results of computational experiments

As a result of the computational experiments were obtained table effectiveness nonparametric shift. An example of such a table is given below for the two samples logistic distribution ($\sigma 1=\sigma 2=1$, $a1=0$). Table 1 shows the probability of making the correct decision (the same shift) as a function of the deviation from one sample to shear another. For a given probability of decision $P=0.97$.

Table 1

№	$a2$ Criterion	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
1	Student	0,963	0,837	0,482	0,135	0,018	0,003	0,001	0,001	0,001	0,001
2	Rank	0,944	0,936	0,908	0,853	0,792	0,708	0,607	0,473	0,384	0,283
3	Haga	0,971	0,974	0,964	0,951	0,943	0,901	0,89	0,858	0,833	0,811
4	E-test	0,967	0,974	0,964	0,966	0,949	0,932	0,932	0,903	0,897	0,862
5	Ken	0,70	0,7	0,70	0,69	0,68	0,68	0,68	0,66	0,66	0,64

		6		7	6	8	2	2	3	3	6
6	V-d-W	0,959	0,931	0,91	0,865	0,787	0,701	0,608	0,496	0,382	0,284
7	Wilcoxon	0,956	0,942	0,927	0,848	0,8	0,71	0,596	0,503	0,383	0,293
8	Median	0,927	0,916	0,88	0,831	0,773	0,722	0,612	0,505	0,434	0,336

According to the results table the graphs (Figure 1).

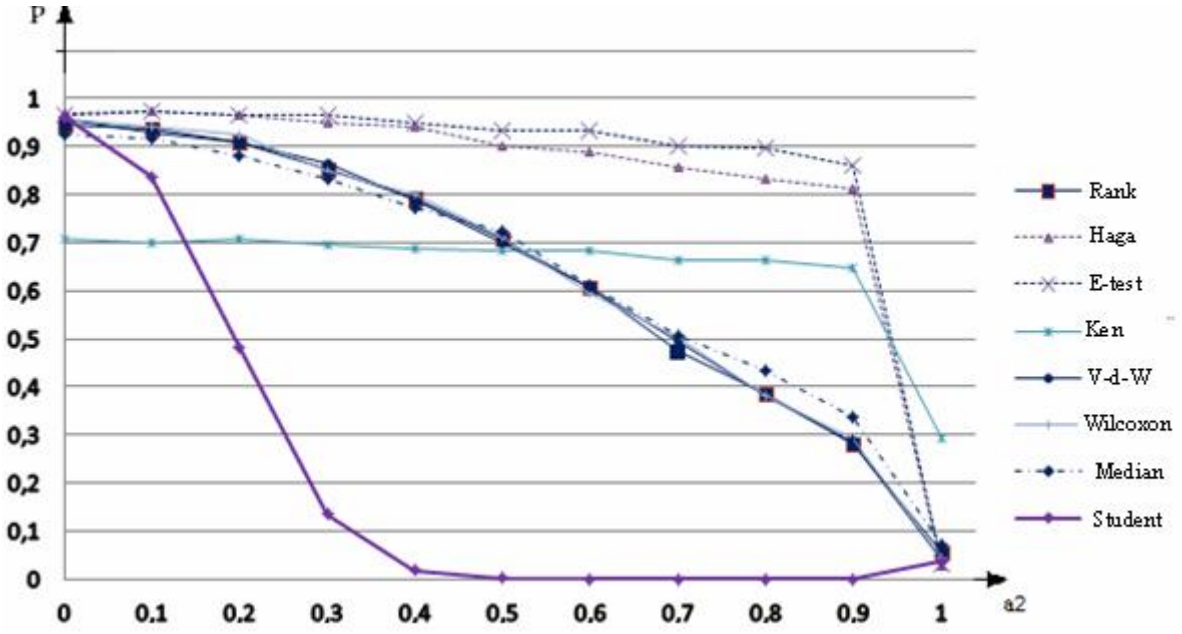

Figure 1. - Probability of detection inequality shifts on the deviation parameter $a2$ from $a1 = 0$.

Table 2 shows an example of performance nonparametric shift when comparing samples with different laws of probability distribution. For the case of comparison of samples with normal and Laplace distributions ($\sigma 1 = \sigma 2 = 1$, $a1 = 0$).The table below shows the probability with which each of the criteria determines the sample as having different shifts.

Table 2

№	$a2$ Criterion	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
1	Student	0,046	0,078	0,186	0,386	0,615	0,802	0,926	0,974	0,993	0,996	1
2	Rank	0,088	0,083	0,156	0,281	0,425	0,589	0,705	0,825	0,907	0,958	0,982

3	Haga	0,07	0,086	0,111	0,149	0,202	0,276	0,358	0,438	0,527	0,609	0,694
4	E-test	0,002	0,004	0,007	0,01	0,016	0,022	0,028	0,039	0,054	0,066	0,085
5	Ken	0,691	0,694	0,6989	0,68	0,669	0,653	0,64	0,624	0,603	0,579	0,553
6	V-d-W	0,04	0,062	0,125	0,241	0,369	0,573	0,717	0,842	0,92	0,976	0,992
7	Wilcoxon	0,039	0,065	0,135	0,272	0,429	0,603	0,766	0,877	0,949	0,978	0,995
8	Median	0,082	0,099	0,173	0,311	0,492	0,632	0,761	0,849	0,915	0,962	0,98

In the case of correlated random variables, we obtain the following results. Is a case of Markov random variables with $a1 = 1$ and the correlation coefficient $r = 0.5$. The results of this experiment are listed in Table 3.

Table 3

№	$a2$ Criterion	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
1	Student	0,247	0,538	0,886	0,987	1	1	1	1	1	1	1
2	Rank	0,254	0,33	0,513	0,718	0,866	0,942	0,984	0,996	1	1	1
3	Haga	0,108	0,152	0,304	0,484	0,669	0,833	0,92	0,971	1	1	1
4	E-test	0,08	0,11	0,219	0,34	0,52	0,661	0,788	0,874	0,925	0,967	0,981
5	Ken	0	0	0	0	0	0	0	0	0	0	0
6	V-d-W	0,275	0,335	0,504	0,704	0,866	0,958	0,983	0,997	1	1	1
7	Wilcoxon	0,25	0,341	0,519	0,714	0,876	0,954	0,988	0,996	1	1	1
8	Median	0,22	0,272	0,507	0,645	0,798	0,922	1	1	1	1	1

Graphs built on the results of Table 3 are shown in Figure 2.

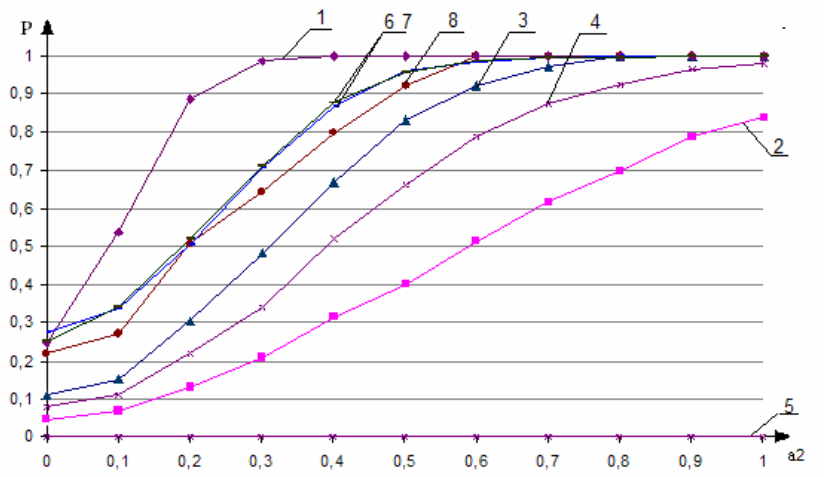

Figure 2 - Probability of detection inequality shifts on the deviation parameter $a2$ from $a1 = 0$, when correlation samples $r = 0.5$.

Of graphs and tables show that Ken is not very effective criterion for any of the cases examined, and the use is not recommended. The median criterion has low efficiency Discriminating between shifts (0.7) for any combination of the laws of distribution of samples of random variables. Unworkable for correlated random variables. E-test has a low efficiency of recognition in the presence of changing shifts, but can be applied to samples of random variables with correlation coefficients up to 0.8. In this case, the criterion distinguishes between two random sampling values as having different shifts, with a probability of 0.87. Hagi criterion does not work for correlated samples. But efficiency is not reduced if the studied sample of random variables have different laws of probability distributions. Rank test is not applicable for correlated random variables. However, its effectiveness (0.8-0.9) is not reduced if the investigated samples have different laws of probability distributions. Criterion Van der Waerden and Wilcoxon identical in their properties. Efficiency of their recognition of inequality shifts of two samples of random variables is 0.8-0.9 for samples with arbitrary and even different kinds of laws of probability distribution. But not applicable to the correlated samples.

Because she statistics for each criterion is a random variable, then in the future will study the effect of the shift amounts to the statistics of each criterion in order to determine on its parameters after the operation state of the object.

Findings

1. Nonparametric criterion shift may only be used in cases when it is known that the investigated samples have the same variance.
2. Recognition of the differences between the two samples shifts breeding values are independent of the type of law probability distribution. Least effective is the criterion Ken.
3. You can not apply the criteria for correlated random variables.

Literature

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