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Performance Evaluaiton of Measuring Instruments Based on Fuzzy Comprehensive Evaluation

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Abstract: In order to make better use of the instruments in the laboratory, the fuzzy compreh-ensive evaluation based on entropy weight method is selected to evaluate the function of the measuring instrument, so as to judge whether the instrument in the laboratory has reached the end of life and improve the utilization of the instrument. Rate and reduce unnecessary losses. Five indicators for judging the quality of the instrument were selected, and their weights were determined according to the entropy weight method to establish a fuzzy comprehensive evalu-ation model. This method is used to judge the experimental equipment of the equal-thickness interference image of light, and the evaluation of the device is “excellent”, which verifies the feasibility of the model.

1. Introduction

In the laboratory for a long time, many instruments were piled up and scrapped after a certain period of time. There is no certain theoretical basis, data support, and sometim-es even if it is bought directly, it will be put on hold, and it will not play its role. It will be scrapped after a certain number of years. Through this research, find a suitable way to make an assessment of the measuring instru-ment and determine whether it can be scrap-ped, increase the availability of measuring instruments, and reduce unnecessary losses. If you can make a scientific judgment on the performance of the instrument measurement, it can improve the efficiency of its measurement and enhance the utilization of the measuring instrument. By evaluating the functionality of the measuring instrument, the utilization rate of the instrument can be promoted, the instrument can be distributed more reasonably, and certain parameters can be adjusted, so that the instrument can reach a good range of use and increase the service life of the instrument.

For a long time, precise mathematics has achieved remarkable results in describing the laws of motion of many things in nature. However, there is still a lot of ambiguity in the objective world. Due to the increasingly complex systems faced by modern technology, ambiguity is always accompanied by complexity.

In practical problems, people's judgments on a thing are often not simple good or bad, but fuzzy language is used to evaluate to different degrees. The objects discussed are often affected by various random factors, and their ambiguity is obvious. In the judgment, a comprehensive evaluation method shall be adopted. The so-called comprehensive evaluation is to make a general evaluation of the events or phenomena affected by a variety of random factors, that is, for the whole object of the judgment, according to the conditions given, each object is given a non-negative real number one evaluation index to engrave According to the nature and characteristics of the object, and then sorted according to this, and draw conclusions.

2. Fuzzy Comprehensive Evalua-tion based on Entropy Weight Method

2.1 Entropy weight method

The basic idea of the entropy weight method is to determine the objective weight according to the magnitude of the index variability. Generally speaking, if the information entropy E_j of an indicator is smaller, it indicates that the index is more variability, and the more information is provided, the greater the role that can be played in the comprehensive evaluation, and the greater the weight. On the contrary, the larger the information entropy E_j of an indicator, the smaller the degree of variability of the indicator, and the less information it provides. The smaller the role played in the comprehensive evaluation, the smaller the weight.

2.1.1 Data standardization

For a given 5 indicators $X_1, X_2, \cdots\cdots, X_5$, among them $X_i = \{x_1, x_2, \cdots\cdots, x_{10}\}$.

Suppose the value of the normalized indicator is $Y_1, Y_2, \cdots\cdots, Y_k$

then:

$$Y_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{1}$$

2.1.2 Find the information entropy of each indicator

Information entropy of a set of data according to the definition of information entropy in information theory:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{2}$$

Among them, $P_{ij} = Y_{ij} \Big/ \sum_{i=1}^{n} Y_{ij}$.

2.1.3 Determine the weight of each indicator

According to the calculation formula of information entropy, the information entropy of each index is calculated as $E_1, E_2, \cdots\cdots, E_5$.

Calculate the weight of each indicator by information entropy:

$$W_i = (1-E_i)/(k-\sum E_i) \quad (3)$$

Among them, $i=(1,2,\cdots\cdots,k)$

2.2 Establish fuzzy comprehensive evaluation Model

The fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. In practical problems, people's judgments on a thing are often not simple good or bad, but fuzzy language is used to evaluate different degrees. Often involved in multiple factors or multiple indicators (standards), we can not judge only one factor, usually using comprehensive evaluation method, which is conducive to improve the scientific and accuracy of the evaluation. In the specific question, the object of the discussion is often influenced by various random factors, and its ambiguity is obvious. The comprehensive evaluation method must be adopted in the judgment. The calculation steps are as follows:

(1) Establish a set of evaluation factors

Factor set $U_i = \{U_1, U_2, U_3, U_4 \cdots\cdots\}$ is a collection of all the factors that affect the outcome of the judgement. It is a common set; factors that are concentrated in the factors usually have varying degrees of ambiguity. The set of factors in this article is U={ Is the accessory on the instrument working properly; Rationality of instrument and equipment selection; After the experiment, can you get the correct data of the standard; Whether the stability index of the instrument is normal; Instrumentation accuracy}.

(2) Create a collection of reviews

The comment set $V_i = \{V_1, V_2, \cdots, V_i, \cdots V_m\}$ is the evaluation level divided into m levels according to the specific requirements, and it is also a common set. The purpose of fuzzy comprehensive evaluation is to obtain an optimal evaluation result from the evaluation level based on comprehensive consideration of all influencing factors. The comment set in this article is V= {excellent, good, moderate, poor}.

(3) Determining the weight set

After assigning weights to each impact indicator based on the entropy weight method, the weight matrix of each factor is obtained. $A = [a_1, a_2, a_3, a_4]$.

(4) Establish fuzzy relation matrix

Establish a fuzzy relation matrix R between evaluation index and evaluation level according to the membership function

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1k} \\ r_{21} & r_{22} & \cdots & r_{2k} \\ & & & \\ r_{n1} & r_{n2} & \cdots & r_{nk} \end{bmatrix} \quad (4)$$

(5) Fuzzy comprehensive evaluation

Suppose A is the weight of the subset of evaluation factors, and R is its evaluation matrix. Then the comprehensive evaluation of the evaluation subset, that is, the evaluation model of the instrument is:

$$B = A \cdot R \quad (5)$$

3. Applications

Application of Entropy Weight Fuzzy Comprehensive Evaluation Method in Performance Evaluation of Measuring Instruments

3.1 Equal thickness interference of light

Taking the experimental study of the equal-thickness interference of light as an example, this experiment studies the interference of light through the Newton's ring and the tip of the ridge, and determines the radius of curvature of the lens.

When a convex surface of a plano-convex lens with a large radius of curvature is placed on an optical flat glass, an upper surface is formed as a spherical surface between the convex surface of the lens and the flat glass, and the lower surface is a flat air thin layer whose thickness is from the center contact point to The edges gradually increase. At the same distance from the contact point, the thickness is the same, and the trajectory of the thick film is a circle centered on the contact point.

The radius of curvature of the lens is:

$$R = \frac{D_m^2 - D_n^2}{4(m-n)\lambda} \tag{6}$$

R is related to the difference in the number of rings $(m-n)$. For $D_m^2 - D_n^2$, it can be proved by the geometric relationship that the square difference between the diameters of the two concentric circles is equal to the square difference of the corresponding chord.

In this experiment, the wavelength of the incident light is known $(\lambda = 589.3nm)$, as long as D_m, D_n is measured, the radius of curvature of the lens can be obtained. An example of an experimental result of an instrument is shown in Table 1 below:

Table 1 Results of a Newton's ring experiment

		left		D_M
15	28.413	10	27.864	9.836
14	28.31	9	27.803	9.742
13	28.221	8	27.789	9.575
12	28.131	7	27.672	9.396
11	28.023	6	27.513	9.2

		right		Dn	R
15	18.577	10	18.942	8.922	0.5052
14	18.568	9	19.021	8.782	0.5240
13	18.646	8	19.118	8.671	0.4860
12	18.735	7	19.217	8.455	0.4949
11	18.823	6	19.321	8.192	0.5166

3.2 Determining weight

After assigning weights to each impact indicator based on the entropy weight method, the weight matrix of each factor is obtained:

$$A = [0.1, 0.1, 0.5, 0.2, 0.1]$$

3.3 Confirm the comment set

Confirm the comment set:

V={excellent,good,moderate,poor}, Constructing a fuzzy relation matrix of an experimental instrument based on the evaluation of experimental operation and results of five experimental students and five experimental instructors:

$$R = \begin{bmatrix} 0.7 & 0.2 & 0.1 & 0 \\ 0.8 & 0.2 & 0 & 0 \\ 0.6 & 0.2 & 0.2 & 0 \\ 0.2 & 0.4 & 0.1 & 0.3 \\ 0.3 & 0.3 & 0.3 & 0.1 \end{bmatrix}$$

R_i is the evaluation matrix composed of the i-th row. For example, R_1 indicates that 70% of the people participating in the scoring think that the accessories on the instrument can be used normally, and 20% think that the accessories on the instrument can be used normally. The performance is good, 10% of people think that the accessories on the instrument can be used normally, and no one thinks that the accessories on the instrument can be used normally.Evaluation scores are shown in Figure 1.

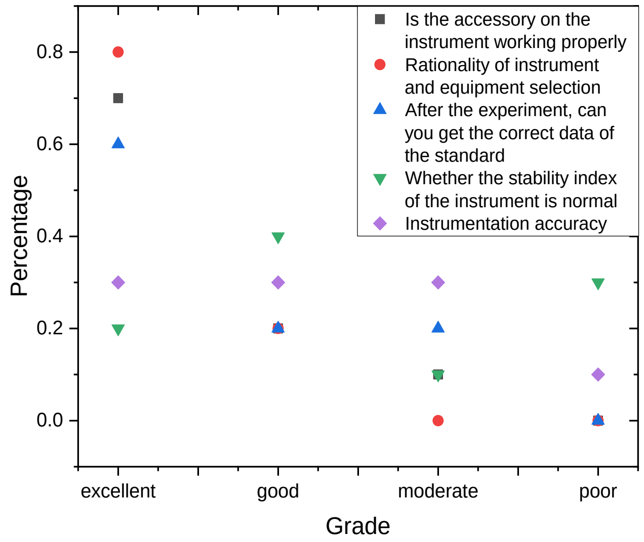

Figure. 1 Fuzzy comprehensive evaluation scores

3.4 Fuzzy comprehensive evaluation

Finally, the fuzzy comprehensive evaluation is performed, and the matrix is combined.

$$B = A \cdot R = \left[0.1, 0.1, 0.5, 0.2, 0.1\right] \cdot \begin{bmatrix} 0.7 & 0.2 & 0.1 & 0 \\ 0.8 & 0.2 & 0 & 0 \\ 0.6 & 0.2 & 0.2 & 0 \\ 0.2 & 0.4 & 0.1 & 0.3 \\ 0.3 & 0.3 & 0.3 & 0.1 \end{bmatrix}$$

$$= \left[0.52, 0.25, 0.16, 0.07\right]$$

According to the principle of maximum membership degree, the maximum value of the evaluation value is taken as the evaluation result, and the evaluation result is 'excellent'.

4. In conclusion

Through this research, we found a suitable method to entropy weight method and fuzzy comprehensive evaluation in information theory.

The combination of judgments. Make an assessment of the laboratory equipment and determine whether it can be scrapped, increase the availability of experimental instruments, and reduce unnecessary losses. Compared with the subjective valuation method, the entropy weight method fully considers the comprehensive correlation effects of each evaluation index, and has higher precision and more objectivity, which can better explain the obtained results. The entropy weight method has certain versatility and can be used in the process of generally determining the weight, or it can be combined with some methods. The degree of difference in the index value is directly used to correct the weight, and no subjective judgment is introduced to the decision maker, and the deviation caused by the human factor is avoided. In the evaluation of experimental instruments, the entropy weight method is combined with the fuzzy comprehensive evaluation, and the distribution of weights is reasonably solved, so that the results of water quality evaluation are more credible. It can more accurately judge the quality of the instrument, promote the utilization of the instrument, distribute the instrument more reasonably, adjust some parameters, so that the instrument can reach a good range of use and increase the service life of the instrument. In the analysis process, good progress has been made, and the laboratory instruments have been comprehensively evaluated, and the opinions of the laboratory equipment management methods have been proposed to the college.

With the wide application of fuzzy mathematics, some problems with ambiguity and subjectivity are quantified and objectivity and science are improved. However, there is another key issue that affects the reliability of the final result. It still has considerable ambiguity and subjectivity. This is the determination of the weight of each indicator. It reflects the status and role of various factors in the comprehensive evaluation, which directly affects the results of the comprehensive evaluation. In fact, different people have different focuses on different indicators. It is generally necessary for a number of experts to repeatedly determine the weight of each indicator, but it is still difficult to be consistent or ambiguous and controversial.

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