An Evaluation Method for Engineering Emergency Repair Measures Based on User Experience Indicators

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Abstract. The choice of remediation measures in a project usually depends on indicators such as the time and money spent on the measure and the impact of its implementation on the surrounding environment. However, these indicators are not able to comprehensively evaluate the good and bad engineering measures, and two empirical indicators are added in this paper for evaluation, which are the indicator of measure utilization rate and the indicator of measure implementation success rate. In today's era of big data, as the number of users using the measures continues to increase, the data on usage and success rates continues to improve, allowing these two indicators to represent the experience of user usage to be preserved. This paper proposes an evaluation method for engineering remediation measures using the extensional evaluation method combined with two empirical indicators. This method solves the problem of passing on experience in the use of engineering remediation measures, so that experienced workers no longer need to instruct new workers in the use of the measures, and the evaluation results for the measures will be more accurate as the use data grows over time. In this paper, we use the extensional evaluation method combined with two empirical indicators to evaluate several engineering measures. The results show that although the measure utilization rate and the measure implementation success rate are new indicators, they can replace some indicators with certain regularity that have not been found to evaluate the merits of the measures more comprehensively.

Keywords: Engineering · Evaluation method · measure · user experience · indicator

1 Introduction

With the rapid development of modern engineering technology, more and more engineering experience is difficult to pass on. Therefore, it is a very serious problem for the contemporary solution to the transmission of knowledge and experience. With the aging of some higher skilled jobs, there is an urgent need for young skilled people to supplement them, but empirical knowledge is difficult to acquire in a very short period of time, so finding a way to make decisions instead of human experience is a very important

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research topic. However, when it comes to engineering problems, it is more about studying the data variation patterns in engineering. [1] propose a data-driven methodology to assess the health state of bridges, by analysing their vibration behaviour. Few scholars have evaluated engineering through user experience data, and in recent years, a number of scholars have conducted research on user experience evaluation. [2] used the User Experience Questionnaire (UEQ) to measure user experience (UX) related to features on The Freeletics Surabaya Sports Community Information System (FLSUB). According to the following components: technological criteria and MOOC indicators, type of users, UX dimensions and UX factors [3], developed a comprehensive framework for the evaluation of UX in MOOC platforms. [4] analyzed cabin evaluation indicators centered on passenger flight experience from the dimensions of passenger flight, aircraft manufacturers design, and airline operation, constructed a comprehensive cabin evaluation system based on cabin space, cabin environment, human-computer interaction, cabin service and other aspects. Based on the SERVPERF model, [5] collected the feedback data of college students and workers to build an index system of map navigation and location service. [6] specified the measurement system of user experience from three dimensions - behavioral performance, sensory perception and psychological experience.

This paper proposes an evaluation method for engineering remediation measures that incorporates user experience indicators. The method involves five evaluation indicators: the cost of the remediation measures, the time required for the remediation measures, the degree of environmental impact of the measures during implementation, the user's measure usage rate, and the user's success rate in using the remediation measures. The evaluation level is divided into five grades: excellent, good, medium, qualified and unqualified.

2 Evaluation Model Based on Extensional Evaluation Method

Since the evaluation indexes in this paper need to determine the merits based on a certain range of values, according to previous scholars, there are involved in the mining geo-environmental quality prediction evaluation [7], reliability evaluation of CNC machine tools [8], the Judgments of Rockburst [9], indoor environment evaluation [10], etc. In this paper, we choose to use the extensional evaluation method [7–10] for evaluation, and the following are the steps to build the mathematical model for the extensional evaluation method.

2.1 Determining the Classical Domain

With m evaluation levels $N_1, N_2, \ldots N_m$, the range of eigenvalues corresponding to each evaluation index is denoted by $[a_{ij}, b_{ij}]$, The classical domain Matter-element R_0 can be expressed as

$$R_0 = \begin{bmatrix} N & N_1 & N_2 & \cdots & N_m \\ c_1 & [a_{11}, b_{11}] & [a_{12}, b_{12}] & \cdots & [a_{1m}, b_{1m}] \\ c_2 & [a_{21}, b_{21}] & [a_{22}, b_{22}] & \cdots & [a_{2m}, b_{2m}] \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ c_n & [a_{n1}, b_{n1}] & [a_{n2}, b_{n2}] & \cdots & [a_{nm}, b_{nm}] \end{bmatrix}$$

In the formula: N_j——the matter-element to be evaluated. N——The entirety of the matter-element $N_1, N_2, \ldots N_m$, to be evaluated. V_{ij}——The quantity value of the ith characteristic of the jth matter-element to be evaluated, $i = 1,2,\ldots,n$; $j = 1,2,\ldots,m$. Combined with the content of this paper the classical domain content can be expressed as

$$R_0 = \begin{bmatrix} \text{Measure evaluation level} & \text{excellent} & \text{good} & \text{medium} & \text{qualified} & \text{unqualified} \\ \text{Cost of measures} & [a_{11}, b_{11}] & [a_{12}, b_{12}] & [a_{13}, b_{13}] & [a_{14}, b_{14}] & [a_{15}, b_{15}] \\ \text{Time required for measures} & [a_{21}, b_{21}] & [a_{22}, b_{22}] & [a_{23}, b_{23}] & [a_{24}, b_{24}] & [a_{25}, b_{25}] \\ \text{Environmental impact of measures} & [a_{31}, b_{31}] & [a_{32}, b_{32}] & [a_{33}, b_{33}] & [a_{34}, b_{34}] & [a_{35}, b_{35}] \\ \text{Measure utilization rate} & [a_{41}, b_{41}] & [a_{42}, b_{42}] & [a_{43}, b_{43}] & [a_{44}, b_{44}] & [a_{45}, b_{45}] \\ \text{Measure success rate} & [a_{51}, b_{51}] & [a_{52}, b_{52}] & [a_{53}, b_{53}] & [a_{54}, b_{54}] & [a_{55}, b_{55}] \end{bmatrix}$$

The lower the cost of the measure the better, the shorter the time required the better, the smaller the impact of the measure on the environment during construction the better, the higher the utilization rate of the measure the better, the higher the success rate of the measure the better.

2.2 Determine the Joint Domain

$$R_p = (P, C, V_p) = \begin{bmatrix} P & c_1 & [a_{1p}, b_{1p}] \\ & c_2 & [a_{2p}, b_{2p}] \\ & \vdots & \vdots \\ & c_n & [a_{np}, b_{np}] \end{bmatrix}$$

In the formula: p——the whole of the evaluation category. $[a_{ip}, b_{ip}]$—— the range of quantities taken by p with respect to c_i, i.e., the joint domain.

2.3 Determining the Matter-Elements to Be Evaluated

For the thing to be evaluated, the monitoring data or analysis results can be expressed in terms of matter-elements as $R_d = \begin{bmatrix} P & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix}$.

In the formula: R_d——the matter-elements to be evaluated. v_i——The value of the thing to be evaluated corresponds to c_i.

Determine the weights of evaluation indicators

$$W_i \geqslant 0 (i = 1, 2, \cdots, n), \quad \sum_{i=1}^{n} W_i = 1.$$

2.4 Determine the Degree of Association

Calculation distance:

$$\rho(v_i, v_{ij}) = \left|v_i - \frac{1}{2}(a_{ij} + b_{ij})\right| - \frac{1}{2}(b_{ij} - a_{ij})$$

$$\rho(v_i, v_{ip}) = \left|v_i - \frac{1}{2}(a_{ip} + b_{ip})\right| - \frac{1}{2}(b_{ip} - a_{ip})$$

In the formula: $\rho(v_{i,} v_{ij})$——The distance between the point v_i and the intervalv_{ij}. $\rho(v_{i,} v_{ip})$——The distance between the point v_i and the interval v_{ij}.

Calculate the association function:

$$K_j(v_i) = \begin{cases} \dfrac{\rho(v_i, v_{ij})}{\rho(v_i, v_{ip}) - \rho(v_i, v_{ij})} & v_i \notin v_{ij} \\ \dfrac{-\rho(v_i, v_{ij})}{\left|v_{ij}\right|} & v_i \in v_{ij} \end{cases}$$

$K_j(v_i)$——association function, the attribution of the indicator c_i of the thing to be evaluated with respect to category j.
$|v_{ij}|$——The length of the interval $[a_{ij},b_{ij}]$, i.e., $|b_{ij}$-$a_{ij}|$.

Calculation of association: $K_j(p) = \sum_{i=1}^{n} W_i K_j(v_i)$.

In the formula:$K_j(P)$——The combined value of the correlation of each indicator c_i of the thing to be evaluated with respect to category j, considering the indicator weights.

2.5 Determine the Category and Level Variable Characteristic Values of the Things to Be Evaluated

If $K_{j0}(P) = \max K_j(P)(j = 1,2,\ldots,m)$, then p is assessed to belong to category $j0$. Notation:

$$\overline{K_j}(p) = \frac{K_j(p) - \min\limits_{1 \leqslant j \leqslant m} K_j(p)}{\max\limits_{1 \leqslant j \leqslant m} K_j(p) - \min\limits_{1 \leqslant j \leqslant m} K_j(p)}$$

Then the level variable eigenvalue j^* of p is:

$$j^* = \frac{\sum_{j=1}^{m} j \bullet \overline{K_j}(p)}{\sum_{j=1}^{m} \overline{K_j}(p)}$$

3 Application Examples

The measures taken by a waterway management office after the damage or erosion of waterway facilities and their evaluation indexes are shown in Table 1 Five measures evaluation indexes, Table 2 Measure evaluation parameters and grading standards.

In order to ensure the objectivity of the evaluation results, all the weights are equal, and the value is 0.2. The evaluation results are calculated according to the extensional evaluation method to obtain Table 3.

The evaluation result is decided according to the evaluation level corresponding to the column where the maximum value of each row of data is located. The maximum value of measure 1 is 0.0184, which corresponds to excellent, therefore the evaluation result of measure 1 is excellent; the maximum value of measure 2 is -0.2086, which corresponds to qualified, therefore the evaluation result of measure 2 is qualified; the maximum value of measure 3 is -0.1609, which corresponds to medium, therefore the evaluation result of measure 3 is medium; the maximum value of measure 4 is 0.0300, which corresponds to good, therefore the evaluation result of measure 4 is good; the maximum value of measure 5 is -0.2868, which corresponds to excellent, therefore the

Table 1. Five measures evaluation indicators

Measures that can be taken	Cost of measures	Time required for measures	Environmental impact of measures	Measure utilization rate	Measure success rate
Measure1	546	10	0.1	90%	90%
Measure2	4254	25	0.11	50%	66%
Measure3	2433	33	0.38	90%	90%
Measure4	1112	16	0.6	78%	87%
Measure5	3343	40	0.43	95%	90%

Table 2. Measures evaluation parameters and grading standards

Measure evaluation level	Cost of measures	Time required for measures	Environmental impact of measures	Measure utilization rate	Measure success rate
Excellent	(500,1000]	(2,10]	(0.1,0.2]	(90,100]	(90,100]
Good	(1000,2000]	(10,18]	(0.2,0.3]	(80,90]	(80,90]
Medium	(2000,3000]	(18,26]	(0.3,0.4]	(70,80]	(70,80]
Qualified	(3000,4000]	(26,34]	(0.4,0.5]	(60,70]	(60,70]
unqualified	(4000,5000]	(34,42]	(0.5,1]	(0,60]	(0,60]

Table 3. Evaluation results

Evaluation area	Excellent	Good	Medium	Qualified	unqualified	*j**	Evaluation results
Measure1	0.0184	-0.3816	-0.6939	-0.7963	-0.8474	1.6028	1 (Excellent)
Measure2	-0.4081	-0.5219	-0.3686	-0.2086	-0.2101	3.7949	4 (Qualified)
Measure3	-0.3072	-0.2060	-0.1609	-0.3004	-0.4695	2.5363	3 (Medium)
Measure4	-0.2990	0.0300	-0.2401	-0.4410	-0.4625	2.1133	2 (Good)
Measure5	-0.2868	-0.4294	-0.4760	-0.3214	-0.3668	2.8959	1 (Excellent)

evaluation result of measure 5 is excellent. The evaluation result of measure 4 is good; the maximum value of measure 5 is -0.2868, which corresponds to excellent, so the evaluation result of measure 5 is excellent. The evaluation result can be concluded that measure 1 and measure 5 are the best, and measure 2 is the worst relative to other measures.

As more user usage data becomes available, the user usage rate and the success rate of user usage measures will gradually become accurate. The user utilization rate is not only correlated with the cost of the measure and the time spent on the measure, but also with the skills of local workers to implement the measure. The lower the cost of the measure, the more likely it is to be used by users, and the shorter the time it takes to perform the measure, the more likely it is to be used by users. The fact that local construction workers do not have the skills to construct some of the measures can lead to a decrease in the use of the measures. Since the construction workers with common skills occupy the majority, it will lead to the users tend to choose some measures with common technology. This paper proposed an evaluation method combined with user data, which can analyze the optimal engineering measures more comprehensively and thus help engineering managers to make a reasonable decision.

4 Conclusions

The main work of this paper is to propose a practical method for evaluating engineering measures. The traditional evaluation method does not include two indicators of user usage and user success rate, but only selects measures by the amount of money spent on engineering measures, the time spent, and the degree of damage to the environment during the implementation of the measures. The evaluation method of engineering emergency repair measures based on user experience indicators proposed in this paper that can make full use of user data combined with actual traditional methods to derive comprehensive evaluation results. With the increasing number of users, the user data will become more and more perfect, and the evaluation results of engineering measures will become more and more accurate.

The value of the method is that it can provide some reference value for other related measure evaluation methods. If the algorithm is written into the decision support system, a user-use database is established as a way to fully call up the data of each evaluation indicator. With different construction prices of measures in different periods, technical upgrades of measures, gradually shorter time spent on implementing measures, and less and less damage to the environment, these data are changing over time. With this data it is also possible to study which measures are evolving and progressing over time and which measures have not been progressing.

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