

Applications of Fuzz Comprehensive Evaluation in Display and Control System of Armored Vehicle

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Abstract. In this paper, from the point of view of Man-machine system engineering, the evaluation method of the display and control system is studied based on fuzzy comprehensive evaluation. The determination of the factors system, the weighted value of the factors, the fuzzy evaluation matrixes and the method of overall evaluation is preliminarily expounded. At last, an example is given to show that the proposed method is effective and applicable. It provides a theoretic reference to the integrated display console interface of armored vehicle developing and designing.

Introduction

As the exchange window of information between the crew and armored vehicle, the display and control system is the main channel for access to vehicle information. However, with the information technology widely used in armored vehicles, the display and control interface become increasingly complex. This increases the crew's workload. The lack of an effective system analysis and evaluation during man-machine design process is one of the most important factors [1].

On the basis of comprehensive analysis of the display and control system characteristics, the paper proposes a fuzzy comprehensive evaluation model of the integrated display console interface. The model combines the qualitative and quantitative analysis, compensates the defects of the previous evaluation method. It provides a new approach for the evaluation of complex man-machine system [2].

Evaluation Index System of the Display and Control System

Display and Control System Structure Model. In order to analyze the basic structure of the display and control system, clear the process of human-machine interaction, understand the human-machine operating characteristics, the paper builds the display and control system structure model.

As the Figure 1 shows, the display and control system is divided into seven subsystems, they are machine perception, machine thinking, actuating mechanism, person perception, manual handing, locomotory and man-machine interface. The subsystems are interrelated and interact on each other. This indicates that, in order to build the index system, not only the hardware and software of the system, but also the crew should be equally important considered.

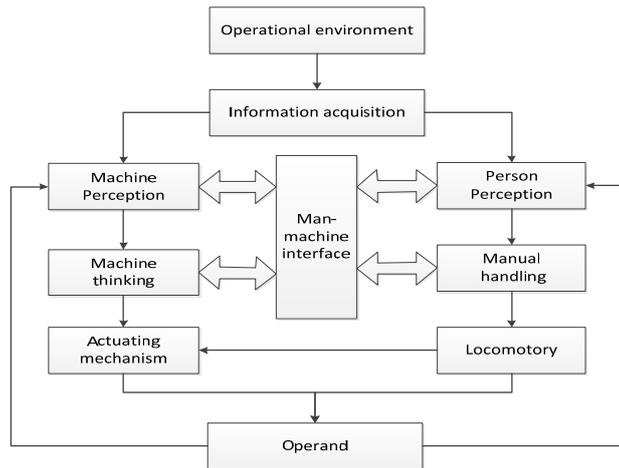


Fig. 1 Structure model of display and control system

Evaluation Index System. The synthetic display level and the composite control level do direct impacts on the implementation and completion of the combat missions. Meanwhile, the crew and vehicle interaction ergonomics has a direct reflection of the comfort of the cockpit environment. The level of man-machine cooperation reflects the rationality of the system man-machine function assignment. In the process of completion of the display and control tasks, technological advance is the guarantee. Through the above analysis, the primary factor sets are as follows: synthetic display level, integrated technical level, composite control level, man machine effectiveness level and coordination level. The secondary factor sets determined and so on, as shown in Figure 2.

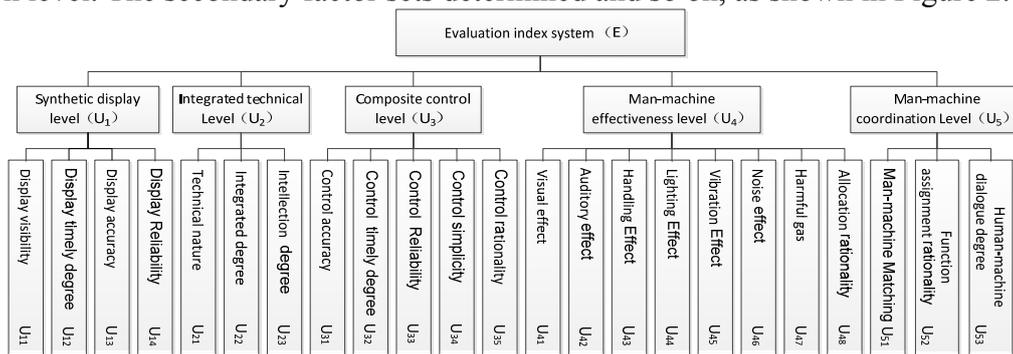


Fig. 2 Evaluation index system

Fuzzy Comprehensive Evaluation Model

All Levels of Factors Set and Evaluation Set. First, the primary factor sets are created: $U = \{U_1, U_2, U_3, U_4, U_5\}$. The secondary factor sets are as follows: $U_1 = \{U_{11}, U_{12}, U_{13}, U_{14}\}$, $U_2 = \{U_{21}, U_{22}, U_{23}\}$, $U_3 = \{U_{31}, U_{32}, U_{33}, U_{34}, U_{35}\}$, $U_4 = \{U_{41}, U_{42}, U_{43}, U_{44}, U_{45}, U_{46}, U_{47}, U_{48}\}$, $U_5 = \{U_{51}, U_{52}, U_{53}\}$.

Then, the evaluation set is divided into five categories: $V = \{V_1, V_2, V_3, V_4, V_5\} = \{\text{good, better, general, worse, bad}\}$. Percentage system grading method is used to the evaluation results. The fractional intervals middle value is as the level geometric parameter of the display and control system [3]. And the score interval and the grade parameter are shown in Table 1.

Table 1 Score interval and grade parameter

Evaluation Set V					
Reviews	good	better	general	worse	bad
Score interval	[90-100]	[80-90]	[70-80]	[60-70]	[50-60]
Grade parameter	95	85	75	65	55

Weight Set. As a fuzzy subset, the weight set reflects the degree of importance of the event in the system [4]. In order to give the weighting certain creditability, the weighting coefficients are graded. The weights range [0,1] is divided into five levels, they are [0,0.2],[0.2,0.4],[0.4,0.6],[0.6,0.8],[0.8,1]. For each evaluation index, the probability is counted in the weighted interval. And then draw weight vector composed of each evaluation index by

calculating the expected value. So the weight vector can be determined as: $\omega = \{a_1, a_2, \dots, a_n\}$ $a_j \in [0,1]$, $\sum_{i=1}^n a_i = 1$.

Fuzzy Evaluation Matrix. A fuzzy mapping is established from the factor set to the evaluation set. $f: U \rightarrow F(V)$, $u_i \rightarrow r_{i1}/v_1 + r_{i2}/v_2 + r_{i3}/v_3 + \dots + r_{im}/v_m$, $0 \leq r_{ij} \leq 1$, $i=1,2,\dots, n$, $j=1,2,\dots, m$. Then, fuzzy evaluation matrix $R = (r_{ij})_{n \times m}$ is generated based on r_{ij} .

Application Examples

Determine the index weight. Based on the above evaluation steps, a fuzzy comprehensive evaluation on man-machine display and control system of a new type armored vehicle is conducted. Six experts who are familiar with the display and control system of the armored vehicles are invited in the evaluation process. The results of index weights are given by the experts in accordance with the method for determining the weight set. 10 experienced armored vehicle crews responsible for different duties are invited to vote for the evaluation of the factors set combined with typical combat missions[5]. The weights and scores of factors set of human-computer display and control system are shown in Table 2.

Establish the levels of fuzzy evaluation matrixes. According to Table 2, we can get the

evaluation matrix $R_1 = \begin{bmatrix} 0.2 & 0.4 & 0.2 & 0.2 & 0 \\ 0.3 & 0.3 & 0.3 & 0.1 & 0 \\ 0.4 & 0.2 & 0.3 & 0.1 & 0 \\ 0.2 & 0.3 & 0.3 & 0.2 & 0 \end{bmatrix}$, the weight set $\omega_1 = (0.20, 0.27, 0.27, 0.26)$.

Based on Fuzzy Comprehensive evaluation formula,

$B = \omega \circ R = (b_1, b_2, \dots, b_m)$ (\circ is the fuzzy operator) (1)

We can get the result of Comprehensive evaluation is $B_1 = (0.2810, 0.2930, 0.2800, 0.1460, 0)$, Similarly available:

$B_2 = (0.3900, 0.3400, 0.2350, 0.0350, 0)$; $B_3 = (0.4000, 0.3400, 0.2040, 0.0560, 0)$;

$B_4 = (0.3750, 0.3450, 0.1750, 0.1050, 0)$; $B_5 = (0.1940, 0.3540, 0.3940, 0.0580, 0)$.

After being arranged: $R = \begin{bmatrix} 0.2810 & 0.2930 & 0.2800 & 0.1460 & 0 \\ 0.3900 & 0.3400 & 0.2350 & 0.0350 & 0 \\ 0.4000 & 0.3400 & 0.2040 & 0.0560 & 0 \\ 0.3750 & 0.3450 & 0.1750 & 0.1050 & 0 \\ 0.1940 & 0.3540 & 0.3940 & 0.0580 & 0 \end{bmatrix}$.

Table 2 Evaluation results of the display and control system

Factor set				Evaluation Set				
primary factor set	weight	secondary factor set	weight	good	better	general	worse	bad
synthetic display level	0.20	Display visibility	0.20	2	4	2	2	0
		Display timely degree	0.27	3	3	3	1	0
		Display accuracy	0.27	4	2	3	1	0
		Display Reliability	0.26	2	3	3	2	0
Integrated technical Level	0.20	Technical nature	0.45	5	3	2	0	0
		Integrated degree	0.35	3	3	3	1	0
		Intellection degree	0.20	3	5	2	0	0
Composite control level	0.28	Control accuracy	0.20	6	1	2	1	0
		Control timely degree	0.22	5	2	3	0	0
		Control Reliability	0.22	2	6	2	0	0
		Control simplicity	0.18	4	5	1	0	0
		Control rationality	0.18	3	3	2	2	0
Man-machine effectiveness	0.20	Visual effect	0.18	6	3	0	1	0
		Auditory effect	0.16	5	2	2	1	0

level		Handling Effect	0.22	2	6	2	0	0
		Lighting Effect	0.07	3	1	5	1	0
		Vibration Effect	0.08	3	2	2	3	0
		Noise effect	0.10	4	4	2	0	0
		Harmful gas	0.09	2	6	2	0	0
		Allocation rationality	0.10	4	4	1	1	0
Man-machine coordination Level	0.12	Man-machine Matching	0.32	1	6	2	1	0
		Function assignment rationality	0.42	2	5	2	1	0
		Human-machine dialogue degree	0.26	3	3	2	1	1

Results and Analysis. According to the formula (1),

$$B = \omega \circ R = (0.20, 0.20, 0.28, 0.20, 0.12) \circ \begin{bmatrix} 0.2810 & 0.2930 & 0.2800 & 0.1460 & 0 \\ 0.3900 & 0.3400 & 0.2350 & 0.0350 & 0 \\ 0.4000 & 0.3400 & 0.2040 & 0.0560 & 0 \\ 0.3750 & 0.3450 & 0.1750 & 0.1050 & 0 \\ 0.1940 & 0.3540 & 0.3940 & 0.0580 & 0 \end{bmatrix} = (0.3445, 0.3333, 0.2424, 0.0798, 0).$$

Comprehensive evaluation of the display and control system score:
 $Q = (0.3445, 0.3333, 0.2424, 0.0798, 0) \circ (95, 85, 75, 65, 55)^T = 84.425$.

We can see from the comprehensive evaluation score, the crew is quite satisfied with the display and control system of the armored vehicle.

Conclusions

This paper presents a multi-level fuzzy comprehensive evaluation method which is benefit for improving the evaluation effect. Starting with the establishing of a multi-level evaluation index system from the man-machine engineering point of view, this paper determined the evaluation factors, weight values of the factors, fuzzy evaluation matrix, and the comprehensive evaluation method. Finally a quantitative evaluation result was unfolded. It has important significance for the evaluation of the man-machine display and control systems.

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