

Health Assessment Based on D-S Evidence Theory of Equipment

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Abstract—Prognosis and Health Management (PHM) is the important technical means to achieve condition based maintenance(CBM), and Health assessment is the important part of the PHM system. PHM is widely used in aerospace area, But it lacks application in ground field, In order to improve the accuracy of self-propelled gun system health assessment, taking a certain self-propelled gun system as the object, in this paper, takes self-propelled gun as an example, divide it's health status into 5 levels, for equipment that fails the test, it can be directly determined to be in a fault state; for equipment that has passed the test, and come up with a model of health assessment that based on D-S evidence theory, first, Select the health indicators which can comprehensively represent the status of propelled artillery, and use the normalized quantization method to Process the data. Then, employ the D-S evidence theory to make the integrated decision on the membership of each health parameter after treatment, finally, determine the ultimately health status of self-propelled artillery, the rationality of the method is verified by experiments.

Keywords-Self-Propelled Guns; D-S Evidence Theory; Health Assessment

I. INTRODUCTION

At present, the elimination of equipment's abnormal state mainly rely on regular maintenance and break down maintenance, and that exposes many disadvantages in the modern equipment maintenance support activities. Under such circumstances, the need for condition based maintenance(CBM) is increasing. Under this background, PHM was born at the right moment. Health assessment is an important function of equipped PHM system, Make correct assessment of the health status of equipment, not only provide a basis for equipment fault prediction and maintenance decision, and provide technical support for the accuracy of equipment maintenance, and it is of great significance to performance, operational and environment of improve the combat effectiveness and service life of artillery.in this paper, take self-propelled guns as the research object to carry out health assessment research. From the perspective of health status assessment, first, Select the health indicators which can comprehensively represent the status of propelled artillery, and use the normalized quantization method to Process the data. Then employ the D-S evidence theory to make the integrated decision on the membership of each health parameter after treatment, finally, determine the ultimately health status of self-propelled artillery.

II. HEALTH ASSESSMENT SYSTEM AND HEALTH CLASSIFICATION

A. Analysis of health indicators

To evaluate the health status of self-propelled artillery, the health status parameters of each system should be determined. In order to evaluate the health of self-propelled gun effectively, it is necessary to determine the health parameters of each self-propelled gun system. The following factors should be taken into account when selecting the parameters of self-propelled artillery's health state assessment:

- 1) Selected parameters can effectively represent the health state of the equipment;
- 2) The selected parameters should be convenient for collection and mutually independent;
- 3) Consider the use factor.

There are many test items for self-propelled artillery, and different items represent different performance. To establish a comprehensive and reasonable health index system is the first problem to be solved for

self-propelled artillery health assessment. The establishment of a health indicator system should consider both comprehensiveness and incompatibility. The performance testing content of self-propelled gun mainly includes performance, maneuverability and environment. Self-propelled gun is a complex system, and the environment is harsh, under the existing conditions, it is impossible to measure all the indicators. To analyze and evaluate the health status of artillery, the key factors should be extracted from the perspective of reflecting the artillery, rather than using all indicators.

Figure 1 shows the health evaluation system of self-propelled artillery.

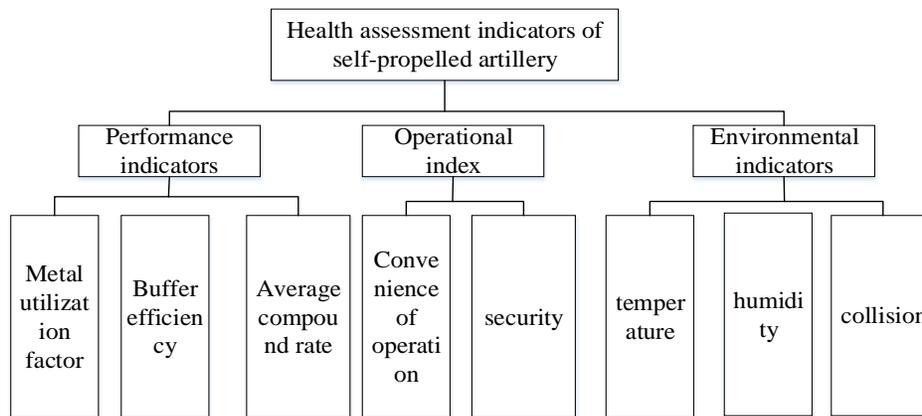


Figure 1. Health assessment indicators

The health indicators of self-propelled guns are divided into three parts: performance indicators, operation indicators, and environmental indicators. In terms of performance indicators, in order to facilitate the quantification, from the perspective of reflecting the performance of the artillery, three factors that can

reflect the quality and health of the artillery are extracted to evaluate the overall health of the artillery. Its set is $u=(u_1,u_2,u_3)$, where u_1 is the metal utilization coefficient; u_2 is the buffer efficiency; u_3 is the average Re-advance rate. The muzzle momentum metal utilization factor refers to the muzzle momentum

provided by the mass of the artillery, which is a comprehensive consideration of the power and mobility of the artillery; the buffer efficiency and the average return speed are used to measure the launch speed of the artillery.

The environmental information is mainly the environmental information of the operating scene of the self-propelled artillery system. The operating scene of the self-propelled artillery system is largely restricted by the environment, and its performance is also affected by environmental factors, thereby affecting its health level. Therefore, environmental information is also an indispensable data for evaluating the operating status of the system; The operation mode of modern self-propelled artillery weapon system has changed from manual to semi-automatic and fully automatic, and the driving mode has also changed from towed to self-propelled. The interaction between the gunner and the artillery is more diversified, and the space for movement is further restricted. The relationship between environment and environment is more complicated. This article starts from the operational requirements of "convenience, safety, and accuracy", and focuses on examining the impact of artillery and the environment on personnel. Based on this, the main factors affecting the operability of the artillery are maneuverability factors and safety factors. Maneuverability factors refer to factors that directly affect the completion quality of operations or reduce operational efficiency, and safety factors refer to factors that affect the safe use of artillery.

B. Health status classification

In the past, when evaluating the health status of self-propelled artillery, the "right-and-no" system was often used, that is, the health status of self-propelled guns was simply divided into qualified and unqualified. It is reasonable that the test data falls within the specified threshold range, and it is not to exceed the specified threshold. This "yes or no" assessment method may use the same maintenance strategy for

equipment that is in very good condition and equipment that is close to failure. This will cause unnecessary repairs for the former, and may cause insufficient repairs for the latter. It affects its combat readiness and cannot achieve condition based maintenance of equipment. Therefore, it is considered to refine the level of equipment health. However, the classification of health status levels should not be too many, otherwise it may not be possible to determine which maintenance measures to take for equipment with different health status levels. According to the requirements, the status of self-propelled artillery (or indicators) can be divided into 5 status levels of health, good, attention, deterioration and failure, as shown in Table 1 below.

TABLE I HEALTH STATUS LEVELS AND DESCRIPTION

Health grade	grade description
health	The measured data are in the range and close to the standard parameter values, don't require maintenance.
good	The measured data are all in the range, and some data are wandering in a small range, but far from the attention value, maintained as planned, Scheduled maintenance.
attention	The measured data are all within the range, and most of them swim and fail to reach the attention value.
deterioration	The measured data are all within the range, but some data are close to the attention value, which needs to be monitored and repaired as soon as possible.
failure	Some data have exceeded the value of attention and must be repaired and secured immediately.

According to the above definition, it can be considered that the state of health and good state belong to health, and the state of attention and deteriorating state belong to sub-health. The self-propelled artillery in "healthy" and "sub-healthy" states is qualified because the test data of all

parameters are within the allowable range. However, for "sub-healthy" self-propelled artillery, it is necessary to attract the attention of maintenance personnel. In a certain period of time in the future, the self-propelled artillery in this state is likely to degenerate into a malfunctioning state, so monitoring must be strengthened. For a self-propelled artillery in a malfunctioning state, because the parameter test data exceeds the threshold, it is unqualified. In order to ensure its combat readiness and mission success, reasonable maintenance measures must be arranged immediately.

It should be mentioned that the state parameter of the system index does not necessarily indicate the health status level, and there is not necessarily a clear boundary between the two. It is necessary to normalize the membership function to transform the state parameter into the state level.

III. HEALTH STATUS ASSESSMENT BASED ON D-S EVIDENCE THEORY

Since the health status of self-propelled artillery is represented by the health status of multiple parameters, in order to determine the health status of self-propelled artillery, it is necessary to evaluate the health status of its parameters and determine the health status of each parameter. According to the health status classification of self-propelled gun, when evaluating the health status of parameters of self-propelled gun, we should first judge whether the parameters are out of tolerance according to the test results of parameters. If the test results of parameters exceed the threshold value, it indicates that the parameters are unqualified, then the self-propelled gun can be directly judged to be in fault state. Otherwise, it shows that the parameters are qualified and need to be further analyzed. The following is a health assessment of the parameters that pass the test. Without explanation, the parameters in this paper refer to the parameters that pass the test.

A. D-S Evidence Theory

D-S evidence theory aims at the results (evidence) after the occurrence of an event and explores the main causes (hypothesis) of the occurrence of an event. D-S evidence theory is an effective method to integrate subjective uncertain information for multi-attribute decision problems with subjective uncertain judgment. The D-S evidence theory was proposed by Dempster in 1967 and was further developed and perfected by his student Shafer in 1976, so it is also called the D-S evidence theory. D-S evidence theory is currently become one of the important tools for processing uncertain information and fusing multiple inference results. It can comprehensively consider the weight of each information in multi-source information and reduce the divergence of conclusions caused by multi-source information inference. The basic theory and methods will be introduced below.

1) Establishment of identification framework

In D-S theory of evidence, propositions are generally represented by sets, that is, questions that need to be decided, collection of all possible answers said with Θ , the set Θ is called recognition framework, and can be represented as: $\Theta = \{\theta_1, \theta_2, \dots, \theta_n\}$, that is to say, by limited element of n (these elements are independent of each other and mutually exclusive) constitute a non-empty set Θ for recognition framework, can be used to represent all the possibilities of events, and called 2^Θ . Proposition A can be expressed as A subset of Θ , namely $A \subseteq \Theta$, or $A \in 2^\Theta$. For each subset Θ can assign a probability, known as the basic probability distribution. For example, a flashlight can emit light of A, B and C , then the identification frame is $\Theta = \{A, B, C\}$, and result is $2^\Theta = \{\emptyset, \{A\}, \{B\}, \{C\}, \{A, B\}, \{A, C\}, \{B, C\}, \{A, B, C\}\}$. And in this paper, the health status of self-propelled

artillery is divided into five levels, health, good, attention, deterioration and failure.

2) *Basic trust allocation function*

The recognition framework contains N elements, and the basic trust allocation $m(A)$ of some evidence on this recognition framework. Is a collection of from 2^Θ mapping to $[0,1]$. For any $A \subseteq \Theta$, such as function $m(A) \rightarrow [0,1]$ satisfy conditions:

$$\begin{cases} m(A) = 0, A = \phi \\ \sum_{A \subseteq \Theta} m(A) = 1, A \neq \phi \end{cases} \quad (1)$$

Then called $m(A)$ is basic trust distribution function in recognition framework Θ . for any subset of A in Θ Framework, if $m(A) > 0$, called A as focal element. $m(A)$ indicates the degree of trust in A by the evidence. $m(\phi) = 0$, reflecting the fact that non credibility in empty sets (empty propositions).

When $A \subseteq \Theta$, and A consists of single element, $m(A)$ is the appropriate precise trust to A propositions; When $A \subseteq \Theta, A \neq \Theta$, and A is composed of multiple elements, $m(A)$ is precise trust to A propositions, is also the corresponding proposition but this part of which of the trust don't know should be assigned to the specific element of A; When $A = \Theta$, then $m(A)$ is the rest portion after each subset of Θ to do the trust assignment, and don't know how to allocate to it.

3) *The trust function and likelihood function*

There is the identification framework $\Theta, m(A)$ is the basic probability assignment on Θ , and there is a mapping $Bel: 2^\Theta \rightarrow [0,1]$ and $Pl: 2^\Theta \rightarrow [0,1]$, satisfying:

$$\begin{cases} Bel(A) = \sum_{B \in A} m(B) \\ Pl(A) = \sum_{B \cap A \neq \phi} m(B) \end{cases} \quad (2)$$

The $Bel(\cdot)$ and $Pl(\cdot)$ functions in the formula, the former is used to represent the function trust function, and the latter is used to represent the likelihood function. The likelihood function $Bel(\cdot)$ and the trust function $Pl(\cdot)$ represent the upper and lower limits of the trust level of A primitive, Specifically, the following can be used to characterize the relationship between the two: $Pl(A) \geq Bel(A), A \subseteq \Omega$. In this way, When measuring the uncertainty of A, $[Bel(A), Pl(A)]$ Can be introduced, And on this basis, Define the probability of event A as $P(A) \in [Bel(A), Pl(A)]$. And the relationship between likelihood function and trust function is shown in Figure 2 below.

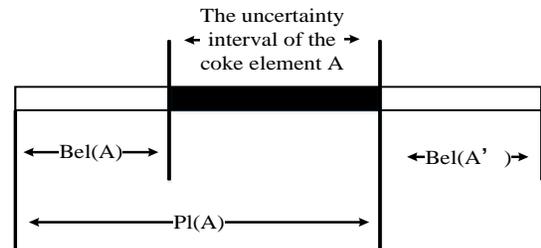


Figure 2. Trust function and likelihood function relationship

4) *The synthesis rules of D-S evidence theory.*

According to the definition of evidence theory, for the evaluating of framework for Θ , different features can obtain evidence of the different body probability distribution value m_1, m_2, \dots, m_n , then the combined process of the probability distribution of each evidence body is as follows:

$$m(A) = \begin{cases} \frac{1}{1-K} \sum_{\cap A_i = A} \prod_{1 \leq i \leq N} m_i(A_i), A \neq \phi \\ 0, A = \phi \end{cases} \quad (3)$$

In the formula, $K = \sum_{\cap A_i = \phi} \prod_{1 \leq i \leq N} m_i(A_i)$.

The D-S evidence theory synthesis principle can be summarized as $m(A) = m_1 \oplus m_2$. For the combination

of multiple evidence, $M = m_1 \oplus m_2 \oplus \dots \oplus m_n$, that can be generalized from the combination of the two evidences. And the K in the formula is used to represent the conflict between various evidences. K is 0 is a consistent evidence, used to indicate that there is no conflict. If the value is close to 1, the greater the conflict.

5) *Decision of health status level*

After the improved evidence theory is applied to synthesize the health status of multiple equipment parameters, in order to determine the final health status of the equipment, the decision method based on the basic probability assignment can be used to make a decision on the resultant health status of multiple equipment parameters, namely, the principle of maximum attribution.

Set $\exists A_1, A_2 \subset U$ as two health status levels of self-propelled artillery, which can be satisfied

$$m(A_1) = \max \{m(A_i), A_i \subset U\}, \tag{4}$$

$$m(A_2) = \max \{m(A_i), A_i \subset U \text{ and } A_i \neq A_1\}, \tag{5}$$

For the pre-set threshold ε_1 and ε_2 , if

$$\begin{cases} m(A_1) - m(A_2) > \varepsilon_1 \\ m(U) < \varepsilon_2 \\ m(A_1) > m(U) \end{cases} \tag{6}$$

If so, the probability of A_1 is much higher than A_2 , the final health state of self-propelled gun can be determined by this method. That is, the final health status of self-propelled artillery is A_1 .

B. Steps based on D-S evidence fusion

There is an uncertain corresponding relationship between the health status of self-propelled artillery and its performance, operation, environment and other factors, which is fuzzy and unknown. Therefore, D-S evidence theory is introduced to carry out data fusion in the health assessment of self-propelled artillery. In the health assessment of self-propelled artillery, several indicators will produce a certain health state, and each indicator of health state has a certain probability of occurrence. In the D-S evidence theory, the probability is represented by the basic credibility distribution, and the different locations of the transmitter are tested by multiple sensors to obtain the basic credibility distribution that the measured indicators of each sensor belong to various health states. Then the D-S combination rule is used for information fusion to obtain the merged health assessment indicators.

The steps of health state assessment of self-propelled artillery based on evidence theory are shown in Figure 3.

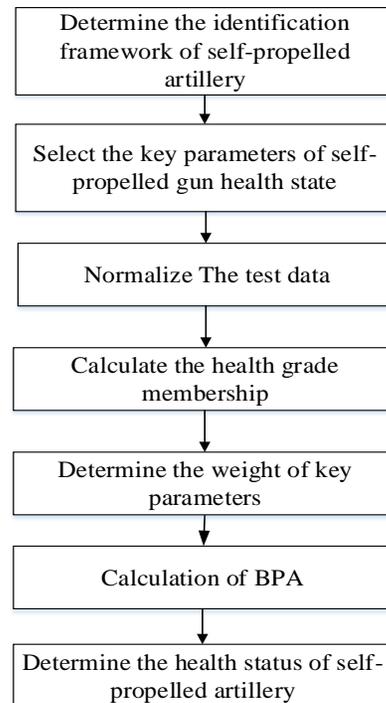


Figure 3. Health assessment procedures for equipment

As can be seen from the figure above, the health status assessment steps of self-propelled artillery are as follows:

1) *Determine the identification framework*

Determine evaluation identification framework, such as dividing the health status of self-propelled artillery into five levels of health, good, attention, deterioration and failure.

2) *Select the key parameters reflecting the health status of self-propelled artillery*

The selection of health parameters of self-propelled artillery is shown in the previous chapter.

3) *Normalization processing of data*

Health assessment of the self-propelled guns, the most important job is to process the data by normalization, assume that select n independent and effective reaction self-propelled guns health test parameters, in order to make these parameters can better describe the self-propelled guns health status, to the test values, respectively, and the fault test values, history and the last time test, compare the mean and standard values, therefore, the test data of normalized processing includes three items: this test data with the last time the breakdown test data comparison values, Comparison values of the test data with historical non-failure test mean and comparison values of the test data with standard data. Since the three comparison values are calculated in the same way, the normalization of the calculated test data and the historical non-fault test mean is illustrated below.

First of all, Calculated value deviation, the absolute value of the deviation between the current test data and the historical test data mean is calculated, If the test value of a parameter is X and the average value of the historical non-fault tests is X_L , then the deviation between the two is:

$$\delta_L = |x - x_L| \tag{7}$$

Secondly, select the normalized quantization function. According to the relationship between the test data and the mean value of the historical non-fault test, the semi-trapezoidal normalized quantization function was selected in this paper to calculate the health parameters more accurately, as shown in Figure 4.

Finally, calculate the normalized value. According to the normalized quantized trapezoidal function selected in the figure, the normalized value of the deviation between the test data and the mean value of the historical non-fault test data is

$$\lambda_L = \begin{cases} 1(\delta_L \leq 0.3\delta_0) \\ \frac{\delta_0 - \delta_L}{0.7\delta_0} (0.3\delta_0 > \delta_L < \delta_0) \\ 0(\delta_L > \delta_0) \end{cases} \tag{8}$$

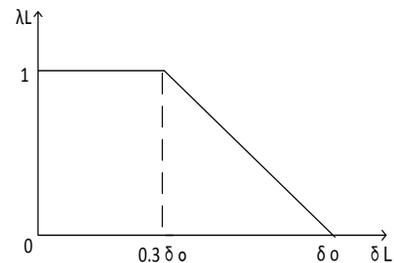


Figure 4. Half trapezoid normalized quantization function

Where, δ_0 is the max error limit. Using the same method, the normalized value λ_S of the test data compared to the last non-failure test data and the normalized value λ_B of the test data compared to the standard data can be obtained.

If $\lambda_L, \lambda_S, \lambda_B$, are all equal to 1, the self-propelled gun is "healthy," and don't exist Health hazard; If all the three are between 0.7 and 1, it means that the health status of self-propelled artillery is acceptable, and the average value of the health status index is taken. If any

of the three is less than 0.7 and greater than 0, it indicates that there may be health risks. The health status index is the minimum value of three. If any of the three is 0, it indicates that self-propelled artillery is in a state of "disease". Therefore, the health status value of self-propelled artillery is:

$$\lambda = \begin{cases} 1(\lambda_L = \lambda_S = \lambda_B = 1) \\ \frac{\lambda_L + \lambda_S + \lambda_B}{3} (0.7 \leq \lambda_L, \lambda_S, \lambda_B < 1) \\ \min(\lambda_L, \lambda_S, \lambda_B) (0 < \lambda_L \text{ or } \lambda_S \text{ or } \lambda_B < 0.7) \\ 0(\lambda_L \text{ or } \lambda_S \text{ or } \lambda_B = 0) \end{cases} \quad (9)$$

4) Determine the membership degree of parameter health status grade

According to the classification of the health status of the equipment, the health status, good status, attention status, deterioration status and failure status of the equipment are fuzzy, that is, due to the lack of an obvious transition from one health status level to another, the uncertainty is non-random and can be expressed by fuzzy set theory. The idea of fuzzy set is to fuzzy the absolute membership relationship in the classical set, so that the membership degree of an element to the set is no longer limited to 0 or 1, but can take any value on the interval [0,1], which reflects the membership degree of an element to the set.

According to the test data, if the data is exceeded threshold value, the self-propelled gun can be judged to be ineffective. There are only fuzzy transition areas between state levels, with no clear boundaries. For example, self-propelled artillery on the edge of health-good state may be in both a healthy state and a good state, but the membership degrees of self-propelled artillery under the two states are different, so it is necessary to make a unified decision on the self-propelled artillery's health state and determine its health level. Since the normalized value of the test data is a representation of the health status of the parameters, the membership function of the parameters can be determined according to the

normalized value of the test data. At the same time, due to the simple shape of the triangular membership function and the small difference from other more complex membership functions, this paper adopts the triangular membership function. According to the actual situation of equipment health degradation and expert experience, the triangular membership function of equipment parameters can be obtained, as shown in Figure 5.

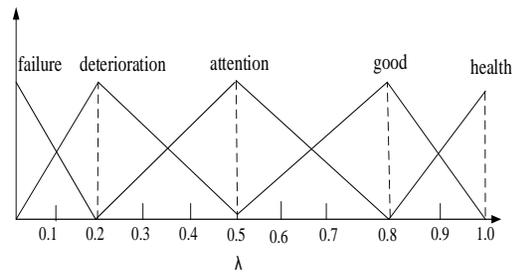


Figure 5. Membership function of fuzzy trigonometric functions

Can be seen from the figure 5, based on triangular membership functions, each param is affiliated with the health status of two adjacent levels, namely the health status of self-propelled guns parameter may belong to two adjacent healthy level in any one, but its membership may be different, and equipment belong to the adjacent two health level of the sum of membership degree of 1.

5) Calculate the weight of parameters

The weight is a measure to characterize the importance degree of evaluation index. To accurately evaluate the health status of self-propelled gun, the weight of each parameter should be determined. Since the normalized value of the test data represents the health state of the parameters, the smaller the normalized value is, the greater the deviation of the parameters from the standard value will be, and the worse their health state will be. Therefore, when evaluating the health status of the equipment, a few parameters with poor health status should be highlighted, that is, the worse the health status of the parameters, the smaller the normalized value and the

greater the weight. In order to determine the weight according to the health state of the parameter, the objective weight of each parameter can be obtained by taking the reciprocal of the normalized value of each parameter and dividing the obtained result by the reciprocal of the normalized value of all parameters. The self-propelled gun has n parameters, the normalized value of $i(i = 1, 2, \dots, n)$ is λ_i , the weight of the parameter can be expressed as:

$$\omega_{i^*} = \frac{1}{\lambda_i} \bigg/ \sum_{i=1}^n \frac{1}{\lambda_i} \quad (10)$$

It can be seen from the formula that the smaller normalized value of the parameter is, the greater its weight will be. When the normalized value of a certain parameter is 0, it indicates that the test result of this parameter reaches the specified threshold value. At this time, the weight of this parameter is 1, while the weight of other parameters is 0. The health state of self-propelled gun can be judged directly according to the health state of this parameter, which is consistent with the actual situation.

6) Calculate the basic trust allocation function

When the D-S combination rule is applied to synthesize the health state of multiple parameters of the equipment, the synthesis formula of evidence theory considers that the importance of the evidence provided by all parameters is the same in the synthesis process. In fact, as one of the two parameters of the health status of serious deterioration, equipment integrated health status also fell sharply, namely the health status of equipment by a small number of the influence of the parameters of the poor state of health is larger, the evidence of each parameter in the process of evidence synthesis important degree is different, so it is necessary to introduce in the process of evidence

synthesis can describe important evidence. The weight coefficient of degree is as follows:

After normalized by the weight formula in the above formula, the relative weight of the it's evidence parameter can be obtained as follows:

$$\omega_i = \frac{\omega_{i^*}}{\max_{i=1..n} \omega_{i^*}} \quad (11)$$

Set the maximum value of the relative weight parameter of evidence in this paper as 0.9, then the basic trust allocation function after weighted adjustment is:

$$\begin{cases} m_i(A_k) = \omega_i m_{i^*}(A_k), i = 1 \dots n \\ m_i(\theta) = 1 - \sum_{k=1}^N m_i(A_k), k = 1 \dots n \end{cases} \quad (12)$$

Where, $m_i(A_k)$ is the basic trust allocation function before the weighted correction, $m_i(A_k)$ is the basic trust allocation function after the weighted correction, A_k is the single element focal element in the recognition framework, and N is the number of elements in the recognition framework.

7) Determine the level of health through evidence fusion

D-S (Dempster-Shafer) Evidence theory that uses the combination of Dempster's rule to integrate the knowledge or data of different experts or data sources, so that different descriptions of the same problem can be focused and one of them can be judged generative information has been widely used in information fusion, expert system, multi-attribute decision making and other fields.

According to the synthesis rules of D-S evidence theory, the basic trust allocation function $m(A)$ of

multiple evidence fusion is calculated by the following formula.

$$m(A) = \frac{1}{1-k} \sum_{\cap A_i=A} \prod_{1 \leq i \leq N} m_i(A_i) \quad (13)$$

In the formula, $K = \sum_{\cap A_i=\Phi} m_i(A_i)$.

The state of health of self-propelled artillery is determined after the combination of evidence rules that is applied to the fusion of multiple evidence. After the evidence source correction is completed, information fusion can be carried out through the evidence theory, so as to obtain the health level of self-propelled artillery system. The specific process will be analyzed in the next chapter with examples.

IV. THE APPLICATION CASE

For example, as self-propelled guns, according to the test data, select five key parameters as test data for self-propelled guns' health status evaluation index, self-propelled guns has six test known, did not experience any maintenance, the sixth five parameters test results are qualified, in order to determine the health status of self-propelled guns, to assess the health status of the 6th test. First of all, according to the type (7), (8), (9), the test data of 5 test qualified parameters were normalized, can get the normalized value is (0.7817, 1.0000, 0.8087, 0.8534, 0.7688).

Since the normalized value of the test data is the representation of the health status of the parameters, in order to visually represent the health status of the five parameters of the equipment, a unit circle can be made and divided into 5 equal parts to obtain 5 radii. The length of each radius is 1, which is the maximum normalized value of each parameter test data, so that the normalized value of each parameter test data I can be represented as a point on the I radius, and the closer lambda I is to the center of the circle, the smaller the normalized value of the test data, the poorer the health of the parameters. By connecting the normalized values of the five parameters on the unit circle, the multi-parameter health status curve of the equipment can be obtained. Because its shape is similar to radar, it can be called health state radar chart, as shown in Figure 6.

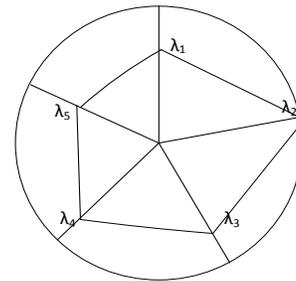


Figure 6. Health condition radar chart of parameters

The weight of each parameter should be determined according to Equation (10). The results are shown in Table 2.

TABLE II HEALTH STATUS ASSESSMENT RESULTS OF SELF-PROPELLED ARTILLERY PARAMETERS

Param	Normalized Value	Health Status Grade Membership					Weight
		Health	Good	Attention	Deterioration	Failure	
1	0.7817	0	0.939	0.061	0	0	0.214
2	1.0000	1	0	0	0	0	0.167
3	0.8087	0.0435	0.9565	0	0	0	0.206
4	0.8534	0.267	0.733	0	0	0	0.196
5	0.7688	0	0.896	0.104	0	0	0.217

In order to better represent the health status of the parameters, In order to analyze potential failures, after determining the membership degree of the parameter, that is, after assigning its basic probability, it can be known that the weight of the last one is the largest. Therefore, the weight of other parameters can be

divided by the weight of the last parameter to determine its "discount rate". And according to Equations (11) and (12), the basic probability assignment after parameter modification is determined, as shown in Table 3

TABLE III BASIC PROBABILITY ASSIGNMENT AFTER PARAMETER MODIFICATION

Modified Parameters	Health Status Grade Membership					Weight
	<i>Health</i>	<i>Good</i>	<i>Attention</i>	<i>Deterioration</i>	<i>Failure</i>	
1	0	0.939	0.061	0	0	0.214
2	1	0	0	0	0	0.167
3	0.0435	0.9565	0	0	0	0.206
4	0.267	0.733	0	0	0	0.196
5	0	0.896	0.104	0	0	0.217

The basic probability assignment in Table 3 is synthesized by the evidence synthesis rule, and final synthesis result is $M = (0.0034, 0.9940, 0.0014, 0, 0, 0.0012)$ and, according to the principle of maximum membership degree, it can be known that the health state of self-guided artillery is "good".

In the same way, to assess the health status of self-propelled artillery from 2015 to 2020, it is known that the assessment results were healthy, healthy, healthy, good, and good. Considering that the state of the self-propelled gun is gradually degraded, the method proposed in this paper is feasible.

V. CONCLUSION

To evaluate the health status of self-propelled artillery, many indicators should be considered. In this paper, from the performance of the self-propelled guns, run indicators and environmental indicators from three aspects, the comprehensive and effective deputies elected to self-propelled guns health status of each index, and the state of the self-propelled guns can be divided into health, well being, attention, degradation state and failure state, better describe the health status of self-propelled guns. Secondly, the state of the

parameters is evaluated. According to the measured data, the normalized value of each parameter is calculated, and the membership degree and weight of each parameter health state are determined. Finally, this paper adopts the fusion method of improved evidence theory and uses D-S evidence theory to fuse the data of various test parameters of health evaluation. The evaluation model of "either/or" is improved effectively, and the rationality of the evaluation model is verified through an example analysis, which is of great reference significance to the improvement of health evaluation methods for self-propelled artillery.

The method proposed in this paper can provide decision basis for health state assessment of self-propelled artillery and has certain reference significance for similar comprehensive health assessment. However, this paper only evaluates the health of the performance indicators, and it is advisable to consider the environmental indicators and operational indicators, as well as the entropy weight method to reduce the subjectivity of weight assignment, which needs to be further improved.

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