Design and development of constructing the basic probability assignment function software in D-S evidence theory

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Abstract. The basic probability assignment function is the basis of D-S evidence theory and the premise of evidence combination. A kind of basic probability assignment function generation software is designed and developed in this paper. After the index values is input, the software can automatically generate the basic probability assignment values, which meet the requirement of the users. The main functions, key algorithms, program logic, development language and interface design of the software are introduced. The calculation case is given to describe the software.

1. Introduction
D-S evidence theory is an effective tool to fuse multi-source information, in which the evidence combination is the basis of the extensive application of D-S evidence theory, and the basic probability assignment function is the key to develop the evidence combination. At present, most of the literatures mainly discuss how to reduce the problem of high conflict in the evidence combination, but there are few discussions on the basic probability assignment construction[1-5]. The simplest basic probability assignment function is the trigonometric function, which is linear and simple, but there are some evidences, whose basic probability assignment is not linear. Therefore, constructing scientific basic probability assignment function is the key to make scientific decision by using D-S evidence theory. Therefore, this paper introduces a kind of software determining the basic probability assignment value, which can construct the basic probability assignment function close to the reality according to the characteristics of the index value.

2. The main functions of software
The main function of the software is to construct the basic probability assignment function for evidence. Considering the index as the evidence, the software has the following functions:

(1) Index increase, state degrade module
This module is mainly to construct the basic probability assignment function of the index, whose state gradually degenerates with the increase of the index value. Given an index value, the excellent probability, good probability, medium probability, poor probability and uncertainty values of the equipment can be obtained.

(2) Index decrease, state degrade module
This module is mainly to construct the basic probability assignment function of the index, whose state gradually degenerates with the decrease of the index value. Given an index value, the excellent probability, good probability, medium probability, poor probability and uncertainty values of the equipment can be obtained.
(3) Index interval is normal, both ends state degrade module

For some indexes, the state is normal when they are in the certain interval, and the state is poor when they are outside the interval. This module is mainly to construct the basic probability assignment function of the specific index. Given an index value, the excellent probability, good probability, medium probability, poor probability and uncertainty values of the equipment can be obtained.

(4) Exit the software

The command is to close the software.

3. Key algorithm

Suppose a certain technical status is divided into 4 levels, namely excellent, good, medium, and poor. Take index increase, state degrade module as an example.

Suppose the rated value of an index is b, and provide the corresponding thresholds c, d, e when its state is degraded. The uncertainty value is β, and x is the index value. The construction steps of the basic probability assignment function of this index are as follows:

(1) The basic probability assignment function to determine the excellent grade

The basic probability assignment function $m_1$ for excellent grade is:

$$m_1 = 1 - \frac{1}{1 + 1.5 \left(\frac{x-b}{c-x}\right)}$$

(2) The basic probability assignment function to determine the good grade

The basic probability assignment function $m_2$ for good grade is:

$$m_2 = e^{\left[2 \left(\frac{e-x}{5.55(c-b)}\right)^2\right]}$$

(3) The basic probability assignment function to determine the medium grade

The basic probability assignment function $m_3$ for medium grade is:

$$m_3 = e^{\left[2 \left(\frac{d-x}{5.55(d-c)}\right)^2\right]}$$

(4) The basic probability assignment function to determine the poor grade

The basic probability assignment function $m_4$ for poor grade is:

$$m_4 = \frac{1}{1 + 1.5 \left(\frac{d-x}{e-x}\right)^2}$$

According to the condition that the sum of the basic probability assignments of a certain evidence is 1, the four basic probability assignments calculated preliminarily are normalized due to the uncertainty value. The processing model is as follows:

$$m_1^* = \frac{m_1}{m_1 + m_2 + m_3 + m_4} \times (1 - \beta)$$

$$m_2^* = \frac{m_2}{m_1 + m_2 + m_3 + m_4} \times (1 - \beta)$$

$$m_3^* = \frac{m_3}{m_1 + m_2 + m_3 + m_4} \times (1 - \beta)$$

$$m_4^* = \frac{m_4}{m_1 + m_2 + m_3 + m_4} \times (1 - \beta)$$

The processed $m_1^*$, $m_2^*$, $m_3^*$, $m_4^*$ and the uncertainty value $\beta$ are the basic probability assignments based on the index.
4. Program logic
The overall program flow chart of the software is shown in Figure 1.

![Flow chart of software program](chart.png)

Figure 1. The overall flow of the basic probability assignment function.

5. Development language and interface design
The software uses the Visual Basic language development interface in the Microsoft Visual Studio 2010 development tool. This software mainly includes 3 main interfaces. The startup interface is shown in Figure 2. The interface of "Index increase, state degrade", and "Index decrease, state degrade" are shown in Figure 3.
6. Calculation case
Take the basic probability assignment of the index whose state gradually degrade with the increase of the index as an example.

After starting the main interface, select "Index increase, state degrade" and click "Next" to enter the basic probability assignment function to build the interface. In the text boxes corresponding to the first threshold, the second threshold, the third threshold, and the fourth threshold, enter 100, 110, 120, and 130 respectively, and enter the uncertainty value as 0.1 and the index value as 98. Click the "Assign" command, and the basic probability assignment based on this index will be calculated. The calculation results are shown in Table 1. The interface of the calculation results is shown in Figure 4. If the threshold cannot be determined quantitatively, the floating ratio can be used to automatically determine the 2, 3 and 4 thresholds based on the baseline value.
Table 1. Results of the basic probability assignment.

| State       | Probability Value |
|-------------|-------------------|
| Degrade     | 0.8194            |
| Excellent   | 0.0803            |
| Good        | 0.0003            |
| Medium      | 0          |
| Poor        | 0.1               |
| Uncertainty |                   |

Figure 4. The basic probability assignment result.

7. Conclusion

According to the relationship between the index and the state, a kind of software to construct the basic probability assignment function with a new method is designed and developed. The software was developed using the Visual Basic language in Visual Studio.Net. The software can set up the basic probability assignment value by itself when the key value of the index is input. The software proposed in this paper has been applied to a certain type of diesel engine technical condition assessment case, which is worth to refer.

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