Research on Radar Importance with Decision Matrix

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Abstract. Considering the characteristic of radar, constructed the evaluation index system of radar importance, established the comprehensive evaluation model based on decision matrix. Finally, by means of an example, the methods of this evaluation on radar importance was right and feasibility.

1. Introduction
At present, the importance of the radar measures include the analytic hierarchy process [1], the multiple attribute decision [2], the cloud theory [3] and fuzzy evaluation [4] and so on, the above method, the determination of index weight more than with the method of qualitative or given in advance, influenced by artificial factors.

In this paper, by analyzing the main factors influencing the importance of radar, based on constructing evaluation index system of radar importance, by the method of evaluating matrix radar compare for grade of target importance sorting, makes up for the past by such means as AHP weight given beforehand, importance to assess the rationality of the improved radar, compared with the traditional method, evaluate simple quickly.

2. Construct the evaluation index system of radar importance
Establishment of evaluation index system should meet the requirements of completeness and independence, embodied in the selection of radar target importance index system, the request for the selected indicators can affect radar importance degree of covering elements, and each index does not exist between the influences each other. The importance of radar depends not only on the performance of the radar itself, but also on the radar on the platform. Therefore, there are two major elements in the index construction that require radar and platform. Features such as platform speed, height, distance and Angle of the target. For radar's own performance, mainly including radar beam width, working frequency, pulse repetition frequency and pulse width, etc, for indices such as the height of the radar, because in the carrying platform has been analyzed, considering the independence principle, the index will not be discussed here.

2.1. Relevant indicators of radar platform
The indicators that measure the importance of radar platform mainly include the speed, height, distance and Angle of the radar platform.

2.1.1. Platform speed. Usually, the faster the radar is attached to the platform, the greater the importance. The quantitative model of this index is,
\[ C_i = \frac{x_i - x_{i\text{min}}}{x_{i\text{max}} - x_{i\text{min}}} \] \hspace{1cm} (1)

2.1.2. **Height of radar platform.** The lower the height of the radar platform, the greater the importance, the main reason is two aspects, one is the height is lower, the more easy to prevent; The second is the relative distance between the height of the target and the relatively short reaction time. The quantitative model of this index is,

\[ C_2 = \frac{x_{2\text{max}} - x_2}{x_{2\text{max}} - x_{2\text{min}}} \] \hspace{1cm} (2)

2.1.3. **Radar platform distance.** Radar platform distance is the distance between the radar platform and the target. Whatever the radar, the closer it is to the target, the greater the importance. The quantitative model of this index is,

\[ C_3 = \frac{x_{3\text{max}} - x_3}{x_{3\text{max}} - x_{3\text{min}}} \] \hspace{1cm} (3)

2.1.4. **The azimuth of the target.** This property is the Angle between the radar and the target. For the convenience of calculation, defines the scope of the azimuth Angle, when the radar platform back to flight, the absolute value of azimuth Angle in, does not pose a importance to targets, define its importance degree is 0. When the absolute value of azimuth is less than, it has a certain importance to the target. The smaller the azimuth Angle, the greater the importance of radar. The quantitative model of this index is,

\[ C_4 = \begin{cases} 
\frac{x_{4\text{max}} - x_4}{x_{4\text{max}} - x_{4\text{min}}}, & 0 \leq x_4 \leq 90^\circ \\
0, & 90^\circ \leq x_4 \leq 180^\circ 
\end{cases} \] \hspace{1cm} (4)

2.2. **Target importance level quantization of technical indicators**
The technical indicators for measuring the importance of radar jamming target mainly include beam width of target radar, working frequency, pulse repetition frequency and pulse width.

2.2.1. **Beamwidth.** Target radar antenna beam width is closely related to the Angle of the radar resolution, when the other parameters of radar close, the smaller the antenna beam width, the Angle of the radar resolution, the better, the greater the importance level of radar. The quantitative model of this index is,

\[ C_5 = \frac{x_{5\text{max}} - x_5}{x_{5\text{max}} - x_{5\text{min}}} \] \hspace{1cm} (5)

2.2.2. **Working frequency.** In the case of antenna size, the higher the frequency of the radar, the better the direction of the antenna, the narrower the beam, the higher the direction accuracy and azimuth resolution. The quantitative model of this index is,
\[ C_6 = \frac{x_6 - x_{6\min}}{x_{6\max} - x_{6\min}} \] (6)

2.2.3. Repetition Frequency. In general, the higher the pulse repetition rate, the greater the importance. There are two main reasons. Firstly, the larger the pulse repetition frequency, the smaller the interference background fluctuation caused by the antenna scanning, the better the radar performance; The second is that the higher the pulse repetition frequency, the higher the effective detection distance of the radar. Usually, the severity of the radiation source was 0.1kHz and the importance level could be considered as 0. When the heavy frequency is greater than 0.1 kHz, the higher the heavy frequency, the greater the importance of radar. The quantitative model of this index is,

\[ C_7 = \begin{cases} 1 - e^{-(x_7 - 0.1)^2}, & x_7 > 0.1 \\ 0, & 0 < x_7 \leq 0.1 \end{cases} \] (7)

2.2.4. Pulse Width. For general pulse radar, pulse width determines the range resolution of radar. The smaller the pulse width, the better the range resolution of the radar, the more it can distinguish the two objects in the same direction. Therefore, when the other working parameters of the radar are similar, the smaller the pulse width, the better the resolution and the higher the importance of radar. The quantitative model of this index is,

\[ C_8 = \frac{x_{8\max} - x_8}{x_{8\max} - x_{8\min}} \] (8)

What’s more, in the formula 1-8, ximax represent the maximum value of the index to be evaluated in the radars; ximin represent the minimum value of the index to be evaluated in the radar; xi represent the Evaluation radar?

3. Standardize the decision matrix and build a standardized decision matrix

The ideal solutions and negative ideal solutions are determined by the following formula,

\[ W^+ = \left\{ \max_{1 \leq i \leq m} W_j^i \right\} = \{W^+_1, W^+_2, \ldots, W^+_8\} \]

\[ W^- = \left\{ \min_{1 \leq i \leq m} W_j^i \right\} = \{W^-_1, W^-_2, \ldots, W^-_8\} \] (9)

The distance between the ideal solution and the negative ideal solution

\[ D^+_i = \sqrt{\sum_{j=1}^{8} (z_{ij} - z^+_j)^2}, \quad i = 1, 2, \ldots, m \]

\[ D^-_i = \sqrt{\sum_{j=1}^{8} (z_{ij} - z^-_j)^2}, \quad i = 1, 2, \ldots, m \] (10)
Calculate the relative closeness of each target solution

\[ W_i = \frac{D^{-i}}{D^{-i} + D^{+i}}, i = 1, 2, \ldots, m \]  

(11)

The degree of proximity is ranked by size, and the greater the proximity, the higher the importance level of the target radar, and vice versa. The relative importance level of the target radar can be determined by sorting all the proximity.

4. The sample analysis

Assuming that the existing four radars are analyzed for their importance, For the four assessed radar, the indicators are as follows,

| NO. | speed(m/s) | height(m) | distance(m) | azimuth(°) | beamwidth(°) | Work frequency /MHz | repetition frequency /KHz | pulsewidth /μs |
|-----|------------|-----------|-------------|------------|--------------|---------------------|--------------------------|--------------|
| 1   | 200        | 3000      | 1200        | 13         | 5            | 20                  | 1.10                     | 5            |
| 2   | 1500       | 300       | 100         | 7          | 12           | 300                 | 1.80                     | 0.1          |
| 3   | 1800       | 2500      | 130         | 10         | 10           | 180                 | 1.35                     | 1.2          |
| 4   | 0          | 0         | 5000        | 45         | 6            | 210                 | 0.95                     | 2.1          |

According to formula (1) - (8), the standardized data is,

| NO. | speed | height | distance | azimuth | beamwidth | Work frequency | repetition frequency | Pulsewidth |
|-----|-------|--------|----------|---------|-----------|----------------|---------------------|------------|
| 1   | 0.11  | 0      | 0.78     | 0.84    | 1         | 0              | 0.63                | 0          |
| 2   | 0.83  | 0.90   | 1        | 1       | 0         | 1              | 0.94                | 1          |
| 3   | 1     | 0.17   | 0.98     | 0.92    | 0.29      | 0.57            | 0.79                | 0.78       |
| 4   | 0     | 1      | 0        | 0       | 0.86      | 0.68            | 0.51                | 0.59       |

According to formula 10, the ideal solution is (0.182, 0.201, 0.090, 0.121, 0.103, 0.125, 0.130, 0.116)  
Negative ideal solution is (0, 0, 0, 0, 0, 0, 0, 0)

Then, according to formula 11, the distance of each radar to the ideal solution is 0.2141, 0.0251, 0.1012

The distance to negative ideal solution is 0.0601, 0.2165, 0.1721, 0.1359

Then, according to formula 12, the proximity of the target radar to the ideal solution is 0.219, 0.896, 0.674, 0.573.

According to the calculation results, radar 2 is the most importanceoned. The importance level is from high to low in order to radar 2, radar 3, radar 4, radar 1.

5. Conclusion

In this paper, the radar importance evaluation index system is constructed and the radar importance evaluation based on the evaluation matrix is put forward, and the rationality of the method is further illustrated by the example. The example shows that it provides a simple and practical method for sorting radar importance, which is easy to implement and has high accuracy.
References

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