Study on the Interactive Decision-Making in Warship Cannon Choosing

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Abstract In this paper a model of warship cannon choosing is established on the basis of interactive decision-making technology. To solve the problem of warship cannon choosing, an interactive model of decision-making is given after analyzing the basic principle of interactive decision-making, whose feasibility is also proved. This model makes the decision-maker more satisfied with the outcome by continuously digging out the relative information of decision problem. The model obeys the objective rule of warship cannon choosing. The authors give an example to illustrate the validity and the practicability of the established model.
Key words Warship cannon; Choosing; Interactive decision-making; Applicability

1 Introduction

Cannon can't be substituted by other weapons in warship. As the development of technology, each country adopts advanced technology to make the cannon improved in some aspects, such as the weight is lighter, the structure is simpler; the reaction is quicker and is roboticized. Cannon presents the characteristic of diversification in order to adapt the different demand of the flat roof of warship [1]. Warship cannon choosing is an important work in the process of warship developing, which affects the campaign efficiency directly. Aiming at the problem of warship cannon choosing, the paper[2] puts forward the way of decision-making through non-fabric fuzzy unit analysis system theory，which reduces the subjectivity of warship cannon choosing but sacrifices part of subjective information. This paper introduces the theory of interactive decision-making, establishing the model of interactive decision-making in warship cannon choosing, which not only can solve the problem in the paper[2], but also improve the degree of satisfaction of decision-makers, the case validates the validity and practicability of the model.

2 Analysis the Theory of Interactive Decision-making

Interactive Method is one of the important ways in the multiattribute decision making, which is a mode gradually approaches the mind, demanding the conversation with the decision-maker in the process. The basic point of this mode is:

(1) The decision making is viewed as an uninterrupted process.

(2) This mode emphasizes the accumulating of change quantity, and achieve the decision aim through uninterrupted correct.

(3) This mode pays attention to the conflict of the finite of the decision-maker's ability and the infinity of the development of objective things, assuring the correctness of decision-making.

Through the way of interactive decision-making, the maker can get the information and prefer information gradually, which can help to make more satisfying decision. The decision-maker should know the result brought by his specifically prefer, so proper model and arithmetic are needed to present the best answer and its rank, each index and the difference between them are also required to presented to the decision-maker in the visual form in order to help to adjust the specifically information. The satisfying answer could be gotten through such interactive process.

The present DSS, NN, emulational decision and artificial intelligence predigest the decision process in a certain extent and replace part analysis, account and broody process, but they can't replace every aspect decided by cerebrum especially in the decision process on arms. Interactive decision-making can make the decision-maker analyze and understand the problem sufficiently and guarantee to do satisfying decision furthest, which is unexampled by other methods. Interactive decision-making is applied in various fields [3-6].

Sum up, interactive decision-making has such three advantages:
(1) Decision-maker can comprehend the decision in-depth and get more impersonal information.
(2) The decision-makers can definitude glad information gradually.
(3) Interactive decision-making can make us more satisfy the result on the problem.

3 Interactive Decision-making in Warship Cannon Choosing

3.1 Interactive decision-making analysis in warship cannon choosing

Warship cannon choosing involves director department in army, use department, manufacture and potential manufacture (suppose that one making unit just produce one type of cannon, so use each manufacture for short). Director department is the organizer and decision-maker, use department and making unit are participants. Different to commonly decision, the cannon is the decision object as each making unit is a decision object in fact.

Besides the common characteristic of artillery, weight, volume, the complex degree of fabric, the nature of fixing should be also considered in cannon choosing. There are various types of cannons, so different cannons have something particular. For example, the cannon AK-630M in Russia and the Phalank, the AK-630M is low consumed, about 20kW, which is only 1/3 of GAU-8/A in Holland; Phalank is tightened with fabric, all equipments of which are installed in one base except the console and telecontrol base. The difference between cannons constitutes many conflicts in choosing, which makes the director department hard to impersonally evaluate cannon unilateral, so conventional decision means can't satisfy the demand.

Interactive decision-making can solve this problem preferably. Firstly, the director department in army consults with the using department to ensure the rule of decision and measure information correspondingly, which is given to manufacture; then each manufacture put forward their individual demand under these rules, which are given to the army; then director department correct the former information on the base of their individual demand; such repeat until every side satisfy. This interactive decision-making can be express as Figure 1:

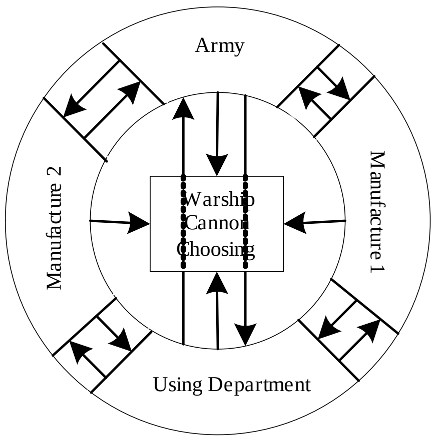

Figure 1 Picture of Warship Cannon Choosing Interactive Decision-making

3.2 Interactive decision-making on cannon choosing

According upwards analysis, make interactive decision-making model on cannon choosing:

Suppose there are n types cannon, namely n manufacture participate in evaluation, each cannon has m indexes. x_{ij} denotes the number j index in the number *i* cannon, w_{ij} is the weight of this index.

The director department gives judged information, ascertain weight range and original weight vector.

(1) Invite *l* expert to give judge information, then *l* weight vectors can be gotten, just as Table 1:

Table 1 Original Weight Vector Given by Experts

Experts	Index One Weight	Index Two Weight	$\cdots$	Index m Weight
1	w_{11}^0	w_{12}^0	$\cdots$	w_{1m}^0
2	w_{21}^0	w_{22}^0	$\cdots$	w_{2m}^0
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
L	w_{l1}^0	w_{l2}^0	$\cdots$	w_{lm}^0

(2) Get the restriction upper limit and restriction lower limit of the weight vectors.

Table 2 Weight Restriction

Restriction Vector	Index One Weight	Index Two Weight	$\cdots$	Index m Weight
Lb（lower limit）	$\min\{w_{i1}^0\}$	$\min\{w_{i2}^0\}$	$\cdots$	$\min\{w_{im}^0\}$
Ub（upper limit）	$\max\{w_{i1}^0\}$	$\max\{w_{i2}^0\}$	$\cdots$	$\max\{w_{im}^0\}$

(3) Synthesize weight vectors to get original reference weight vector $w^{(1)}$ used in decision process. There are many means to synthesize weight vector just as arithmetic average. This paper constructs a set of vector $w^{(1)} = \left(w_1^{(1)}, w_2^{(1)}, \cdots, w_m^{(1)},\right)^T$, which presses closest to other vectors, namely the sum of cosine of system weight vector and other vectors is biggest.

$$Z^* = \max \sum_{k=1}^{l} \cos\theta_k = \max \sum_{k=1}^{l} \frac{(w^{(1)}, w^{E_k})}{\left|w^{(1)}\right|\left|w^{E_k}\right|} \tag{1}$$

$$s.t \quad \begin{cases} w_i^{(1)} > 0, i = 1, 2, ..., m \\ \sum_{i=1}^{m} w_i^{(1)} = 1 \end{cases} \tag{2}$$

θ_k denote the nip angle between $w^{(1)}$ and the weight vector $w^{E_k} = (w_1, w_2, \cdots w_m)^T$ of expert *k*, the cosine of which is:

$$\cos\theta_{ij} = \frac{(w^{(1)}, w^{E_k})}{\left|w^{(1)}\right|\left|w^{E_k}\right|} = \sum_{i=1}^{m} w_i^{(1)} w_{ki}^0 \Bigg/ \sqrt{\sum_{i=1}^{m} (w_i^{(1)})^2 \sum_{i=1}^{m} w_{ki}^2} \tag{3}$$

(4) After ascertaining the original weight vector $w^{(1)}$, director department feed this information back to manufacture. Each manufacture ascertains own weight according their preference.

Adopt linearity adding weight to denote synthesis evaluation result of each type cannon, $\sum_{i=1}^{m} x_{ij} w_{ij}$ is the synthesis evaluation result of unit *i* and w_{ij} is unknown.

For unit *i*, $i=1,\cdots,n$, establish model to calculate w_{ij}

$$Z_i = \max_{w_{ij}} \sum_{j=1}^{m} w_{ij} x_{ij} \tag{4}$$

$$s.t.\begin{cases} \sum_{j=1}^{m} w_{ij} = 1 \\ Lb(j) \le w_{ij} \le Ub(j) \qquad j=1,\cdots,m \\ \sum_{j=1}^{m} w_{ij} x_{ij} \ge T_i \qquad i=1,\cdots,m \end{cases} \tag{5}$$

In the restriction condition $T_i = \sum_{j=1}^{m} w^{(1)} x_{ij}$, which make the synthesis evaluation result of other cannons are not lower than the synthesis evaluation result given by the army based of system reference weight.

(5) Each manufacture feed their weight back to the director department who synthesize these weights to get new reference weights, which are feed back to manufacture again.Repeat until each one satisfy. Prove the model:

Definition $w^{(k+1)}$ and $w^{(k)}$ are two weight vectors of $1\times m$, the distance between which is:

$$d(k+1,k) = \sqrt{\sum_{j=1}^{m} (w_j^{(k+1)} - w_j^{k})^2} \tag{6}$$

Theorem Give a smallest number bigger than 0, the model above must converge, namely there must have a best result $w^{(k+1)}$ that satisfy the condition: $d(k+1,k) < \xi$.

Firstly, $w^{(1)}$ is a result and Φ^1 must have bound, so aim function must have best result.

After give $w^{(1)}$, the best result of unit i is:

$$w_i^{(1)} = (w_{i1}^{(1)}, w_{i2}^{(1)}, \cdots, w_{im}^{(1)})^T, i=1,\cdots,m \tag{7}$$

Get synthesis weight vector $w^{(2)}$ according the means of vector synthesis. $w^{(2)}$ is of course the bit in the Φ^1. So if $d(k+1,k) \ge \xi$, $w^{(2)}$ can replace $w^{(1)}$, then $\Phi^2 \subseteq \Phi^1$.

Seek the best result of unit i in Φ^2:

$$w_i^{(2)} = (w_{i1}^{2}, w_{i2}^{2}, \cdots, w_{im}^{2})^T, i=1,\cdots,n \tag{8}$$

$w^{(3)}$ is the synthesis weight vector and $\Phi^3 \subseteq \Phi^2 \subseteq \Phi^1$ can be known from discursion. So if $d(k+1,k) \ge \xi$, $w^{(k)}$ can replace $w^{(k-1)}$ and seek the best result of unit i in Φ^k. The following can be known:

$$\Phi^{k+1} \subseteq \Phi^{k} \subseteq \cdots \subseteq \Phi^{2} \subseteq \Phi^{1} \qquad (9)$$

After each repetition, the scope of result is reduced and because it has bound, when giving the smallest number $\xi > 0$, there must be the best result $w^{(k+1)}$ to satisfy $d(k+1,k) < \xi, k \in N$, which the model must conver.

4 Case Analysis

Adopt the applicability of cannons as example. Give $\xi = 1E-03$. There are three types of cannons, the attribute of which are shown in Table 3:

Table 3 Attribute Indexes

Cannons	Attributes					
	Weight	Base Radius*	Exploitation	Personnel Weave	Fabric Adaptability	Installing Warship Technique
I	1.92t	2083.46mm	35kVA	0	4	2
II	1.83t	2281.19mm	28kVA	0	3	4
III	2.15t	2384.57mm	40kVA	0	2	3

*Annotate: Volume is scaled by radius of base and exploitation use average exploitation.

Since the structure adaptability and install warship technique are synthesis indexes, the method is:

(1) Define tone arithmetic operators:

Table 4 Mood Arithmetic Operators

	Bad	Relative Bad	Common	Good	Excellent
Mark	1	2	3	4	5

(2) Invite experts to grade the three manufactures. The integration degree, the way of supply bomb and the characteristic of base are the main standards to evaluate the frame adaptability; technique of manufactures, the level of workers and the proportion of specialized workers are used to ascertain install warship technique maturate degree. All three cannons are automatic and there are no people, so we don't consider the effect of people to cannon adaptability.

Weight, volume and exploitation are cathode indexes, so $x_{ij} = \min x_{ij} / x_{ij}$ are used as standard; frame adaptability and install warship technique are anode indexes, so $x_{ij} = x_{ij} / \max x_{ij}$ are used as standard.

(3) Invite four experts to compare indexes in pair, estimate matrix can be obtained.

$$A^{(1)} = \begin{bmatrix} 1 & 1/2 & 2 & 4 & 3 \\ 2 & 1 & 3 & 5 & 4 \\ 1/2 & 1/3 & 1 & 1/2 & 2 \\ 1/4 & 1/5 & 2 & 1 & 2 \\ 1/3 & 1/4 & 1/2 & 1/2 & 1 \end{bmatrix} \quad A^{(2)} = \begin{bmatrix} 1 & 1/2 & 3 & 2 & 4 \\ 2 & 1 & 4 & 5 & 5 \\ 1/3 & 1/4 & 1 & 1/2 & 2 \\ 1/2 & 1/5 & 2 & 1 & 3 \\ 1/4 & 1/5 & 1/2 & 1/3 & 1 \end{bmatrix}$$

$$A^{(3)}=\begin{bmatrix}1 & 2 & 1/2 & 1/4 & 2\\ 1/2 & 1 & 1/4 & 1/3 & 2\\ 2 & 4 & 1 & 2 & 3\\ 4 & 3 & 1/2 & 1 & 5\\ 1/2 & 1/2 & 1/3 & 1/5 & 1\end{bmatrix} \quad A^{(4)}=\begin{bmatrix}1 & 2 & 1/2 & 1/4 & 2\\ 1/2 & 1 & 1/4 & 1/2 & 2\\ 2 & 4 & 1 & 2 & 4\\ 4 & 2 & 1/2 & 1 & 5\\ 1/2 & 1/2 & 1/4 & 1/5 & 1\end{bmatrix}$$

(4) Calculate the model through Matlab requiring four circulations, then ultimate synthesis weight can be gotten. Synthesized weight vector and d_k corresponding are as follows:

Table 5 Results Corresponding to Each Circulation

Circulation	Weight Vectors					d
One	0.2329	0.2362	0.2247	0.2335	0.0727	0.0488827
Two	0.2316	0.2333	0.2277	0.2339	0.0735	0.0044609
Three	0.2314	0.2322	0.2299	0.2333	0.0732	0.0025573
Four	0.2314	0.2319	0.2306	0.2329	0.0732	0.0008602

After four circulations, the decision circulation finishes according to qualification $d_4 < \xi$ and we get the best weight vector, which is used to do the synthesis evaluation of each unit, namely aim function result that is used to rank the cannons, just as Table 6:

Table 6 Synthesis Result and the Rank of Cannons

	Cannon I	Cannon II	Cannon III
Synthesis Result	0.906427	0.921669	0.732349
Rank	2	1	3

According the result, the cannon II is better than cannon I and cannon III in the installing warship adaptability, but cannon I and cannon III are as much as in the synthesis evaluation result, showing the difference is not obvious.

5 Conclusions

This paper analyzes the rule of cannon choosing based on the characteristics of cannon and warship developing. According the theory of interactive decision-making, the interactive decision-making model on cannon choosing is established, which sufficiently considers the demand of each decision maker and unifies the demand into one model, try to satisfying every unit. The case validates the practicability of the model.

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