The Quantitative Assessment Research on Targets Attack Value of Land Battle Unmanned Platform

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Abstract. The determination of multi-target strike value of unmanned combat platform is investigated for the precondition of realizing autonomous decision and attack of unmanned combat platform. By using the linear simplification and scale method, the quantitative assessment result on targets attack value of land battle unmanned platform is presented from the aspects of direct threat and indirect threat, target relative characteristics, environmental characteristics, etc. The quantitative results can provide data support for the multi-target strike sequencing and the rational use of firepower of the unmanned combat platform.

Introduction

Target strike value is the comprehensive measurement of target battlefield value and platform fire to target strike ability. It determines whether the unmanned combat platform will strike a certain target at a specific time and how much firepower will be allocated to strike it. The evaluation and ranking of multi-objective strike value is the premise of the optimal use of firepower and the basis of the full play of the overall combat effectiveness of the multi-objective combat platform.

At present, many achievements have been made in the research on the target strike value evaluation of manned combat platform[1-5], while the research results on the target strike value evaluation of unmanned combat platform are few.

Target Battlefield Value Evaluation Index of the Land Combat Unmanned Combat Platform

The target battlefield value is a comprehensive measure of the target's usefulness to the enemy and its disadvantage to me. On the one hand, the direct threat degree of the target depends on the internal attributes of the target's own firepower performance and maneuverability; on the other hand, it depends on the battlefield environment, relative tactical position of both sides, and the external attributes such as the protection ability of our unmanned platform; on the other hand, the indirect threat degree of the target depends on the target's reconnaissance ability, command and communication ability, and the ability to provide support Force and so on. The specific index composition is shown in Figure 1.
Damage Ability Evaluation Index of Platform Fire to Target

The damage ability of platform firepower to target refers to the ability of unmanned platform to detect, attack and damage the target in specific combat environment. When the target is beyond the effective range of the platform fire, which represents the traffic size of the geographical environment between the two. The specific index composition is shown in Figure 2.

Direct Threat Degree of Target Battlefield Value Evaluation Index Quantification

(1) The platform target distance threat measurement function is

\[ u(s_{ij}) = \begin{cases} 
0.5(1 + \frac{r_j - s_{ij}}{r_j}) & 0 \leq s_{ij} \leq 2r_j \\
0 & s_{ij} > 2r_j 
\end{cases} \]

where \( r_j \) is the effective range of the j-th target, \( s_{ij} \) is the distance between the i-th platform and the j-th target.

(2) The target mobility threat measurement function is

\[ u(v_j) = \frac{v_j}{v_{j_{max}}} u(\theta_j) \]

where \( v_{j_{max}} \) is the maximum speed of the j-th target, \( v_j \) is the current speed of the j-th target, \( u(\theta_j) \) is the measure function of the angle between the moving direction of the target and our target, and

\[ u(\theta_j) = \begin{cases} 
cos(\theta_j) & 0 \leq \theta_j \leq 90^\circ \\
0 & \theta_j > 90^\circ 
\end{cases} \]

where \( \theta_j \) is the angle between the i-th unmanned platform and the j-th target movement direction.

(3) The target effective range measurement function is
where $r_{ai}$ and $r_{bj}$ are the effective range of the $i$th unmanned platform of our side and the $j$th target of the enemy, respectively.

(4) The damage probability measurement function $u(p_{ij}) = p_{ij} \in [0, 1]$, where $p_{ij}$ is the probability of the $j$-th target's hit and damage to our $i$-th unmanned platform.

(5) The response speed measurement function of fire platform is

$$
u \left( \frac{v_{ij}}{v_{fi}} \right) = \begin{cases} 1 & v_{ij} > v_{fi} \\ \frac{v_{ij}}{v_{fi}} & v_{ij} = v_{fi} \\ 0 & v_{ij} < v_{fi} \end{cases},$$

where $v_{ij}$ is the artillery reaction speed of the $j$-th target, and $v_{fi}$ is the artillery reaction speed of the $i$-th platform.

(6) The target payload measurement function is $u(n_j) = \frac{n_j}{n_{j_{max}}}$, where $n_{j_{max}}$ is the maximum carrying capacity of the $j$-th target and $n_j$ is the current carrying capacity of the $j$-th target.

### Indirect Threat Degree of Target Battlefield Value Evaluation Index Quantification

The evaluation of the indirect threat capability of the target is usually described in a qualitative way, such as "strong, weak", etc. In order to realize the automatic evaluation of the command and control system, we use the scale method to quantify the indirect threat capability of the target.

1. **Reconnaissance capability**

   The equipment and means suitable for battlefield reconnaissance of unmanned combat platform are unmanned reconnaissance aircraft, mobile reconnaissance vehicle, reconnaissance post, etc.

   **Table 1. Quantitative assessment of reconnaissance capability.**

   | Reconnaissance equipment | Aerial reconnaissance | Mobile reconnaissance vehicle | Reconnaissance post | Others |
   |---------------------------|-----------------------|------------------------------|---------------------|--------|
   | Reconnaissance capability assessment | 1.0                   | 0.8                          | 0.5                 | 0.2    |

2. **Command capability**

   The battlefield command equipment and means suitable for the unmanned combat platform are command and control system, command organ, command vehicle, etc.

   **Table 2. Quantitative assessment of command capability.**

   | Command equipment | Command and control system | Command organ | Command vehicle and others | Others |
   |-------------------|-----------------------------|---------------|----------------------------|--------|
   | Command capability assessment | 1.0                     | 0.8           | 0.5                        | 0.2    |

3. **Supportability**

   The equipments that participate in the support of the unmanned combat platform are ammunition transport vehicle, battlefield rescue vehicle, logistics supply vehicle, etc.

   **Table 3. Quantitative assessment of support capacity.**

   | Support equipment | Ammunition transport vehicle | Battlefield rescue vehicle | Logistics supply vehicle | Others |
   |-------------------|-------------------------------|-----------------------------|--------------------------|--------|
   | Assessment of supportability | 1.0                          | 0.8                         | 0.5                       | 0.2    |
There are many kinds of enemy targets in the operation of unmanned combat platform low altitude aircraft (armed helicopter, UAV), armored equipment, general vehicles, etc.

| Equipment         | Low altitude aircraft | Armored equipment | General vehicles | Others |
|-------------------|-----------------------|-------------------|------------------|--------|
| Assessment of protection capability | 1.0 | 0.8 | 0.3 | 0.1 |

**Capability Characteristics of the Platform**

Regardless of the environmental factors, if the probability of finding the target in the far range of the effective range \[^{[6]}\] is \( P_f \), the hit probability is \( P_m \), and the damage probability is \( C \). Thus there holds

1. **Probability of finding target**

   The probability of finding the target is related to the performance of the platform sighting device, which can be expressed as \( P_f = \lambda_g p_{ts} \), where \( \lambda_g \) is the performance coefficient of the platform sighting device, \( p_{ts} \) is the probability of finding the target under ideal conditions.

2. **Hit probability**

   The probability of hit is related to the skill of shooter and the performance of artillery, which can be expressed as \( P_m = \lambda_h p_{m} \), where \( \lambda_h \) is the performance coefficient of the gun, \( p_m \) is the platform hit probability under ideal conditions.

3. **Damage probability**

   The damage probability is related to the type of projectile and the protection ability, which can be expressed as \( P_d = \lambda_{dp} p_{ld} \), where \( \lambda_{dp} \) is the bomb type coefficient, \( p_{ld} \) is the damage probability of a specific bomb type to the target.

**Target Characteristics of the Platform**

The factors that affect the target being destroyed mainly include the target's anti Strike ability, anti Strike ability and camouflage and concealment ability.

1. **Target's anti Strike ability**

   The "hard protection" of the target can be expressed as \( A_r = \frac{\lambda_r T_l}{T_{ul}} A_{pr} A_{unit} \), where \( \lambda_r \) is the protective coefficient of armor relative to homogeneous armor, \( T_l \) is the thickness of target armor, \( A_{pr} \) is the special protective ability, \( A_{unit} \) is the protective ability of uniform steel armor per unit thickness, generally \( A_{unit} = 1 \).

2. **Target's anti Strike ability**

   The mathematical model is \( C_M = W_w C_w + W_t C_t + W_v C_v \), where \( C_w, C_t \) and \( C_v \) respectively represent the target weight, target traffic ability and target marching ability values, and \( W_w, W_t \) and \( W_v \) respectively represent the weight of target weight, target passing ability and target marching ability, and \( W_w + W_t + W_v = 1 \).

3. **Camouflage ability**

   The camouflage concealment ability coefficient \( W_{yb} \) is shown in Table 5. If the noncamouflaged target probability to be found is \( p_n \), then the camouflaged target probability to be found is \( p_m = \frac{p_n}{1 + W_{yb}} \).
Table 5. Camouflage concealment ability coefficient $W_{\text{y}}$.

| Camouflage ability | Very good | Good | General | Bad |
|--------------------|-----------|------|---------|-----|
| $W_{\text{y}}$     | 0.9       | 0.8  | 0.6     | 3   |

Environmental Characteristics of the Platform

When evaluating the threat of targets, we must also consider the influence of relative tactical position, terrain visibility, accessibility, terrain conditions, meteorological conditions and other environmental factors.

1. Relative tactical position
The relative position (Tactical distance) index of platform and target depends on the threat measurement function $U_{(s)}$ of platform target distance on the one hand, and also on the membership function $U(\theta)$ of the angle between the target motion direction and platform on the other hand.

2. Intervisibility condition
If $q$ is recorded as terrain visibility and $z$ is the vegetation visibility, the visibility of the platform to the target can be expressed as $q = \frac{S_t}{S}$, where $S_t$ is the area of the unobstructed part of the target, and $S$ is the total area of the target. The values $z$ are as follows:

Table 6. Vegetation Perspective.

| Vegetation classification | No vegetation | Short shrubs | Tall shrubs | Sparse trees |
|---------------------------|---------------|--------------|-------------|--------------|
| $z$                       | 1.0           | 0.8          | 0.5         | 0            |

In this case, the probability $p_{\text{f}}$ of the platform finding the target can be expressed as $p_{\text{f}} = qz p_{0}$, where $p_{0}$ is the probability of finding the target under the condition of no shelter.

3. Access conditions
Whether the platform can strike the target beyond the effective range can be expressed by the accessibility condition $d_T$ of the platform to the target. On the one hand, it depends on the maneuvering speed $v_i$ of the target relative to the unmanned platform, on the other hand, it also depends on the terrain access condition $d_{ij}$ between the unmanned platform and the target $d_T = v_i d_{ij}$, where $v_i > v_j$, $v_j$ is the movement speed of the i-th platform, $v_j$ is the movement speed of the j-th platform.

4. Topographical conditions
For the unmanned combat platform operation, the terrain and surface features of the battlefield mainly affect the shooting hit rate of the platform, so the terrain coefficient can be expressed as $\lambda_{\text{TE}} = qT_d$. The hit probability of unmanned platform considering terrain conditions is $p_{mc} = \lambda_{\text{TE}} \lambda_{\text{m}} P_m$, where $\lambda_{\text{TE}}$ is the terrain coefficient and $q$ will greatly affect the shooting hit probability, $T_d$ is the terrain visibility rate, is the access condition.

5. Meteorological conditions
Different levels have different effects on the shooting hit probability, so the meteorological coefficient $\lambda_{\text{ME}}$ is shown in the table.

Table 7. Meteorological coefficient.

| Battlefield visibility | Very good | Good | General | Poor | Very poor |
|------------------------|-----------|------|---------|------|-----------|
| $\lambda_{\text{ME}}$  | 1.0       | 0.9  | 0.8     | 0.6  | 0.4       |
Conclusion

This paper systematically expounds the quantitative processing method of multi-target strike value index of unmanned combat platform, which provides a quantitative basis for the establishment of threat estimation model of unmanned combat platform in the next step, and is of great significance to improve the autonomous decision-making and attack function of unmanned combat platform.

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