Research on Fire Dispersion Data Processing Method Based on Cloud Model

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Abstract. The dispersion of fire is an important performance indicator of ammunition, which directly affects the operational effectiveness of weapon equipment. According to the characteristics of randomness and fuzziness of the dispersion, this paper introduces the method of cloud model to evaluate the data of the dispersion of one certain type of ammunition which has been identified by test, and generates a comprehensive cloud model according to the established evaluation criteria. Comparing the evaluation results from this cloud model method with the results from some widely used methods at present, it can be concluded that the cloud model method are real and reliable, and more intuitive and clear, and thus its feasibility and effectiveness is verified.

Introduction

The dispersion of ammunition is an important indicator to measure the performance of weapons and equipment, it represents the overall measurement of the deviation of each impact point from the distribution center (average shot point). This deviation comes from the different random differences caused by the inconsistency of weapons, ammunition, meteorology, launching operations and other related factors during the launch (shooting), which can be basically summarized into five aspects: 1. the distribution of the structure size and parameters of ammunition; 2. initial velocity distribution; 3. the accuracy of the structure of weapons and equipment; 4. instantaneous changes in meteorological conditions; 5. random error of operation. This is the essence of dispersion, fully reflects its randomness, and to evaluate the quality of the dispersion index also reflects the ambiguity of the concept of dispersion. Cloud model is a transformation model between qualitative concept and quantitative representation formed by specific structural algorithm based on the interaction between probability theory and fuzzy mathematics theory. Cloud model not only reflects the uncertainty of concept in natural language, but also reflects the relationship between randomness and fuzziness, which constitutes the mutual mapping between qualitative and quantitative.

In this paper, the main theories, techniques and methods of cloud model are summarized, the uncertainty of shooting dispersion is studied by using cloud model, and the idea of further optimizing data processing method is put forward.

Dispersion

There is one method of data processing in the general assessment of the dispersion of the shooting. It is called the dispersion radius method. It is often used for less shooting or dispersion area near the circle, such as rifles, machine guns on the target within 300 meters, or long-range missile launch. With the average shot point as the center of the circle, including 100 % of all the shot point radius called Rₐ₀₀, known as the radius of full dispersion.

We take the full radius of the circle as the evaluation index of the dispersion of a certain type of bullet shape test as an example. This type of bullet dispersion assessment method is based on the test outline according to GJB4388 - 2002 general bullet typing test procedures. The outline of the
assessment methods are: natural temperature, wind speed is not more than 5 m/s, no rain and snow weather. 100 m range, 10 rounds per group, firing n groups. The position of the aiming line and other shooting conditions are not changed during shooting. The trial weapon is a qualified ballistic gun.

The evaluation criterion is that the average value of the radius of full dispersion circle ($R_{100}$) of 10 rounds does not exceed $R$ cm, and the dispersion meets the requirements of tactical and technical indicator.

The method for graphing the radius of the dispersion circle comprises the following steps:

a) The average shot point

Make a horizontal line and a vertical line on the target paper so that both sides of each line have the same number of bullet holes, and the straight line is equidistant from the nearest bullet holes on both sides. The intersection of two straight lines is the average shot point of the group.

b) Calculate the radius of dispersion circle ($R_{100}$)

Draw a circle through the outer edge of the farthest bullet hole with the average shot point as the center of the circle. The radius of this circle is the radius of dispersion circle.

c) Calculate the average (accuracy to 0.1cm)

$$\bar{R}_{100} = \frac{1}{n} \sum_{i=1}^{n} R_{100i}$$

Where $n$ is the number of shooting groups; $R_{100i}$ is the radius of dispersion circle for group $i$.

As you can see in the figure above, the average shot point can be quickly determined by this method, and the radius of the fully dispersed circle can be obtained by measurement. After decades of practice, this method has proved to be mature and feasible. However, this method lacks the analysis of the numerical characteristics of the shot point, but simply checks the degree of dispersion of the shot point relative to the average shot point, and does not check the degree of dispersion of the shot point itself. From the figure above, we also can’t see the dispersion of the shot point intuitively.

**Cloud Theory**

Cloud is an uncertainty transformation model between a qualitative concept expressed by linguistic value and its quantitative representation, which is used to reflect the uncertainty of the concept in natural language, and reflect the relationship between randomness and fuzziness, and constitute the mutual mapping between qualitative and quantitative. Cloud from the basic language value in natural language, research qualitative concept of quantitative methods, intuitive and universal. Qualitative concepts are translated into quantitative values, more vividly, into a point in the domain space. This is a discrete transformation process, with contingency, can be described by probability distribution function.

**Definition of cloud**

Let $U$ be a quantitative field expressed by exact numerical values, $C$ be a qualitative concept on $U$, and if the quantitative value $x$ is a random realization of the qualitative concept $C$, the certainty $\mu(x)$ of $x$ is a random number to $C$ [0,1] with a stable tendency. If $\mu: U \rightarrow [0,1], x \in u, x \rightarrow \mu(x)$, then the distribution of $x$ over the domain $U$ is called a cloud, each $x$ is called a cloud drop.

**Digital characteristics of cloud**
The digital characteristics of the cloud is used to reflect the overall characteristic of the concept. The cloud characterizes a concept as a whole with three digital characteristics: \( Ex \) (Expected value), \( En \) (Entropy), and \( He \) (Hyper Entropy), as shown in figure 2.

- **Ex**
  The expectation of cloud drop distribution in the domain space is the central value of concept in the domain space, and it is the most representative point of qualitative concept.

- **En**
  It is a measure of the uncertainty of qualitative concept, which is determined by the randomness and fuzziness of qualitative concept. \( En \) is a measure of the randomness of the qualitative concept, reflecting the degree of dispersion of cloud drop representing the qualitative concept; At the same time, \( En \) also reflects the margin of the qualitative concept, which reflects the range of values of cloud drop acceptable to the qualitative concept in the domain space, and it is a measure of the fuzziness of the qualitative concept. Using the same numerical characteristics to reflect the randomness and fuzziness, but also reflects the relationship between them.

- **He**

![Figure 2. Digital characteristics of cloud and cloud.](image)

It is a measure of the uncertainty of \( En \), the entropy of entropy, reflecting the cohesion of the uncertainty of all points representing the linguistic value in the theoretical domain space, and its size indirectly reflects the thickness of the cloud.

**Cloud generator**

The transformation process from qualitative concept to quantitative representation is called forward cloud generator, which is composed of three digital characteristics of cloud: expectation, entropy and super entropy through \( CG \sim N^3 (Ex, En, He) \) to produce satisfying cloud drop \((x, \mu)\). \( N \) cloud drops constitute the whole cloud, such a qualitative concept is quantitatively expressed by the transformation of cloud model uncertainty.

The transformation process from quantitative representation to qualitative concepts is called a reverse cloud generator. The reverse cloud generator is the process of obtaining three digital characteristics \((Ex, En, He)\) describing the cloud of qualitative knowledge by knowing a certain number of cloud drops \((x, \mu)\).

**Data Processing Method of Dispersion of Fire Based on Cloud Model**

Thoughts on data processing method of dispersion of fire based on cloud model.

Cloud is a method of describing uncertain problems. The application in the field of ammunition distribution needs to be combined with the relevant expertise of firing dispersion. In the process of shooting, statistics believe that there is a clear definition of shooting. There is no also the middle of each other, including uncertainty, it is called randomness. Fuzzy theory holds that the shooting is relative, depends on the distance from the shot point to the aiming point, it is difficult to define a boundary to divide it accurately, this also contains the uncertainty of each other's events, it is called fuzziness. Shooting can be used to indicate the degree of membership of the shot point to the aiming point.
Cloud theory holds that the shooting is random and the degree of shooting is fuzzy. Each shot point can be regarded as a cloud drop, the overall characteristics of cloud formed after several shots reflect the overall level of dispersion. Cloud method proposed using digital characteristics to describe the whole cloud, to achieve the transformation between qualitative and quantitative. Due to the influence of many random factors, the multiple shot points are approximately normal distribution on the target paper.

Through the study, we find that the three digital characteristics of cloud model and dispersion concepts are similar. \(Ex\), for example, is the position of the center of gravity of all clouds in the number field, equivalent to the average shot point coordinates, reflecting the average shot point relative to the aiming point (\(Ex\) is significant for precision inspection, but it is not significant for the dispersion); \(En\) is the measure of qualitative concept. On the one hand, it reflects the randomness of the shot point, also reflects the dispersion degree relative to the expected value in the horizontal and vertical direction. On the other hand, it reflects the fuzziness of shooting--membership. \(En\) is the key to judge the size of dispersion distribution. He is the degree of dispersion, \(En\)‘s entropy, which reflects the degree of cohesion of the shot point and the uncertainty of membership.

Therefore, we use two-dimensional normal cloud model \((Ex_1, Ex_2; En_1, En_2; He_1, He_2)\) to describe the overall dispersion. In the process of data processing, the right-angle coordinate system is firstly established with the aim point as the origin, and the transverse and longitudinal coordinates of ten shot points are measured. We can use the reverse normal cloud generator to restore the numerical characteristics of the shot point, and calculate the radius of distribution circle, then generate cloud drop through the forward cloud generator, restore the level of the dispersion of ammunition, and predict the dispersion of a large number of projectiles.

Steps for data processing method of dispersion of fire based on cloud model.

Step 1: To construct a two-dimensional reverse cloud generator (fig. 3).

By measuring the horizontal and vertical coordinates of all known shot points, three numerical characteristics of the normal cloud they represent can be calculated: \(Ex_1, Ex_2, En_1, En_2, He_1, He_2\), called the reverse cloud generator.

Step 2: To construct a two-dimensional forward cloud generator (fig. 4).

For the digital characteristics of the two-dimensional normal cloud derived from the first-step inverse cloud generator: \(Ex_1, Ex_2, En_1, En_2, He_1, He_2\), cloud drops can be generated by the following two-dimensional forward normal cloud generator algorithms:

a) To generate a two-dimensional normal random entropy \((Enn_1, Enn_2)\) with a desired value \((En_1, En_2)\) and a mean square deviation \((He_1, He_2)\);

b) To generate a two-dimensional normal random number \((X, Y)\) with a desired value \((Ex_1, Ex_2)\) and a mean square deviation \((Enn_1, Enn_2)\);

c) To repeat steps 1 through 2 until a desired number of cloud drops are generated.

Figure 3. 2-d reverse cloud generator. Figure 4. 2-d forward cloud generator.
Using a two-dimensional forward normal cloud generator to generate different numbers of cloud drops, the dispersion can be restored roughly.

Enter a set of 10 firing shot point coordinates, using the cloud model to restore three sets of 10 and 100 shot points, respectively, each figure first for the actual point diagram, as shown in Figure 5, figure 6.

Conclusion

Aiming at the fuzziness and randomness of the dispersion of ammunition, the cloud model method is introduced, and the dispersion data processing method based on the cloud model is proposed, and the dispersion of a certain type of ammunition which has been tested is analyzed. The results show that cloud model, as a qualitative and quantitative uncertainty transformation model, can reflect the uncertainty of the concept of dispersion. The method solves the problem of uncertainty in the process by determining three digital characteristics of the cloud model, which is composed of a reverse normal cloud generator and a forward normal cloud generator. The results show that the cloud model method is more intuitionistic and clear than the commonly used method and accords with the actual situation of ammunition dispersion.

Reference

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