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Multi-photoelectric detection sensor target information recognition method based on D-S data fusion

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ABSTRACT

To improve the capture rate, recognition rate and weaken the false target influence in multi-photoelectric detection sensor testing system, this paper proposes D-S data fusion recognition processing method to distinguish the real target signal and interference signal when the flying target passes through each unit photoelectric detection screen; structures a new vague D-S data fusion recognition processing model and recognition algorithm based on the principle of four-photoelectric detection sensor testing system and target signal characteristics; researches the reliability probability density function under recognition framework of multi-photoelectric detection sensor testing system, and uses four photoelectric detection sensors as an evidence body to build reliability density function values and obtains different support degrees, and gives detail derivation and analysis. Through experiment and analysis, the results show that the larger support degree signals can be seen as real target signals in the same condition, and the proposed identification method and recognition algorithm can meet the target identification requirement of multi-photoelectric detection sensor testing system.

1. Introduction

Multi-photoelectric detection sensor testing system is a kind of measurement equipment that is used to gain the flying target dynamic parameters in shooting range, it has played an important role in weapon testing field, it can provided scientific data for the development and improvement of weapons, such as, flying target's coordinate, velocity and vertical target density, and so on. Because photoelectric detection sensor testing system mainly works in the outdoors, it is easily interfered by mosquito, sand and other false targets, which makes the detection sensor difficult to identify and judge the real target signal, and influences the testing accuracy and detection performance [1,2].

Multi-photoelectric detection sensor testing system consists of four or six photoelectric detection screens; every photoelectric detection screen consists of a photoelectric detection sensor, slit diaphragm, lens and processing circuit. The optical geometry principle of multi-photoelectric detection sensor testing system can refer to the document [3] and [4]. To one unit photoelectric detection screen, because of its structure and detection feature, it can't identify the real or false target signal under some complex environment, however, multi-photoelectric detection sensor testing system has many merits in shooting range testing, such as, long detection distance, large field of view, flexible layout, and so on, which makes multi-photoelectric detection sensor testing system wide application in multi-projectile target parameters testing field [5]. If we can look for a fast identifying real target algorithm when there is a false target effect on multi-photoelectric detection sensor testing system, which will improve the capture rate, recognition rate and weaken the false target influence, it is very good measure. The traditional target recognition methods mainly use the output signal amplitude's size [6], if there are multiple targets or other interference sources, the traditional identification methods will not be able to identify real target information, which led to the measurement data having a great error.

With the development of weapons, the traditional methods do not meet the needs of the test any longer, thus it is very necessary to discuss and research a new target recognition method to eliminate the false target influence and improve the test accuracy and recognition rate. In this paper, based on the testing principle of four-photoelectric detection sensor testing system, we propose the data fusion recognition theory to structures a new vague D-S data fusion recognition processing model and recognition algorithm, and give the experimental verification.

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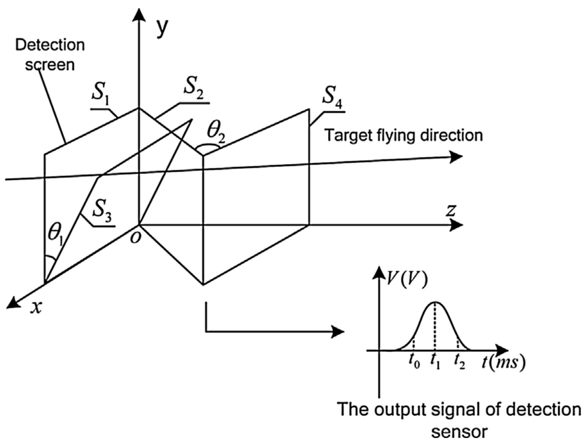

Fig. 1. The space geometric principle of four-photoelectric detection sensor testing system.

2. Four-photoelectric detection sensor testing system and its signal characteristics

Fig. 1 is the space geometric principle of four-photoelectric detection sensor testing system. From Fig. 1, we know the core of the multi-photoelectric detection sensor system mainly consists of four-photoelectric detection sensor and processing algorithm. Suppose, S_1, S_2, S_3 and S_4 are respectively four photoelectric detection screens, and every detection screen consists of photoelectric detection sensor, slit diaphragm, lens and processing circuit.

Based on its space geometric relation, S_1 and S_4 are mutual parallel detection screens and both vertical to ballistic or the level of the ground; here, *oz* is the ballistic direction; *xoz* is the level of the ground. The detection screen S_2 is also vertical to ballistic, but it is not mutually parallel with S_1 and S_4; the detection screen S_3 is not vertical ballistic and also not parallel with S_1, and between the detection screen S_1 and S_3 there is an angle. θ_1 is the angle between detection screen S_1 and S_3, and θ_2 is the angle between detection screen S_2 and S_4, when the flying target passes through four-photoelectric detection screens, we can gain their time between the two detection screens and calculate the parameters of flying target's coordinate and velocity, their calculation model can refer to the document [2] and [3].

From Fig. 1, when targets pass through every photoelectric detection screen, the detection sensor will output instant varied information. We use *f*(t) to denote the output signal, which can be expressed by Formula (1).

$$f(t) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(t-t_0)^2}{2\delta^2}} + n_0(t), t > 0 \tag{1}$$

In (1), $n_0(t)$ is the noises of the circuit system, and the output signal of each photoelectric detection sensor conforms to the normal distribution [7]. Based on the work principle of photoelectric detection screens and signal acquisition method, we can gain the pulse width information of target signals by calculating the sampling point's number and sampling frequency. Fig. 1 shows the output signal curve when the real target passes through photoelectric detection screen. The target entering whole photoelectric detection screen time should be $t - t_0$, t_0 represents time that the real target enters the photoelectric detection screen, t_2 represents time that the real target leaves the photoelectric detection screen time, t_1 represents the output signal's peak time, and then, the output signal pulse width can be determined by Formula (2).

$$\Delta t = t_2 - t_0 = (D + l)/v_0 \tag{2}$$

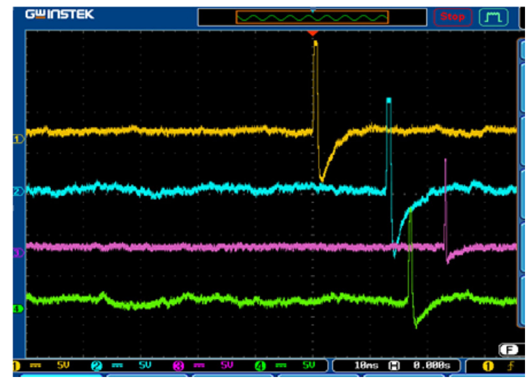

Fig. 2. The output signal when target passes through four- photoelectric detection screens.

In (2), v_0 is the velocity of target flying, *D* is the thickness of photoelectric detection screen, and *l* is the length of flying target. To research the target signal features, we use the optics knowledge to analyze and set up luminous flux model, and the changing luminous flux can be expressed by Formula (3) when real target flies into the whole photoelectric detection screen.

$$\Delta\Phi(t) = E \cdot S \tag{3}$$

In (3), $\Delta\Phi(t)$ is the changing luminous flux when target passes through the photoelectric detection screen, *S* is the shading area of target in screen, and *E* is the background illumination. By the knowledge and characteristics of photoelectric detection sensors, its output signals can be expressed by Formula (4).

$$f_{out}(t) = \Delta\Phi(t) \cdot \varepsilon \cdot \gamma \cdot R \tag{4}$$

In (4), *R* is the equivalent resistance of photoelectric detection system in unit photoelectric detection screen, ε is the response of photoelectric detection sensor, and γ is the magnification of detecting circuit [8].

Based on the four-photoelectric detection sensor testing system, we gather their output signal by using oscilloscope under a testing experiment condition; Fig. 2 is the testing result. From Fig. 2, we find the output signal of each photoelectric detection sensor is basically the same, and there exists time difference, which reflects the space geometry relationship of four-photoelectric detection sensor testing system, and that is to say, the start time of four-photoelectric detection sensor output signal is not the same, and projectile passes the distance of thickness of photoelectric detection screen also is difference. From the output signal characteristics, there are two obvious features: one is the width of signal, and the other is the amplitude; to the same target, the two features are basically same and it conforms to the normal distribution regularity. Based on those known data, we use D-S evidence theory to establish target recognition model and algorithm.

According to Fig. 1, the space geometric principle of four-photoelectric detection sensor testing system is use photoelectric detection screens to set up testing model, four-photoelectric detection screen has its geometric angle, at the same time, the S_1 and S_4 is parallel, when the false target signal and the real target signal appear in photoelectric detection screen, due to the different space location of each photoelectric detection screen, if real target pass through the detection screen of four-photoelectric detection sensor testing system, each photoelectric detection screen will gain the same the pulse width signal, we can use the same the pulse width signal and geometric relation of S_1 to S_4 to judge the real time, for example, we calculate the time S_1 to S_2 or S_1 to S_3 when target pass through the detection screen of S_1 to S_2 and S_1 to S_3 according to the target flight theory speed, and calculate the geometric angle of S_1 to S_2 and S_1 to S_3, if the calculation angle and the practical