Research on Automatic Location Technology and Target Reporting System

Shi Qiu
PLA Army Academy of Artillery and Air Defense, Hefei 230031, China
Qingniaomingyue@126.com

Abstract
It is an important link to judge the shooting performance of light weapons. This paper analyses the main positioning technology and target-reporting system at home and abroad. The application of positioning technology in target-reporting system and its advantages and disadvantages are discussed, and the future development direction of target-reporting system is pointed out.

Keywords
Military equipment; positioning technology; automatic target reporting system.

1. Introduction
Shooting performance is an important index to measure the training effect of shooters and evaluate the performance of weapons. With the great progress of modern science and technology, automatic positioning technology is developing continuously. Based on sensor detection technology, microelectronics technology, artificial intelligence technology, signal processing and computer software and hardware technology, a variety of target-reporting systems have been developed. These target-reporting systems can be divided into the following types: acoustic-electric positioning automatic target-reporting system, target-reporting system based on image processing technology, optical fiber coding positioning target-reporting system, photoelectric sensing automatic target-reporting system, short double-layer electrodes, road sampling system and electrode embedded automatic target reporting system [1].

2. Research Status of Automatic Location Technology and Target Reporting System

2.1 Research status of automatic positioning technology
Target reporting system is generally composed of front-end sensor, data acquisition and processing part and data display part. The front-end sensor is used to capture the signal when the warhead passes through the target surface or directly collect the image information of the target surface. The information processing part calculates the position of the impact point according to the sensor signal and displays the results through the display device. The existing target-reporting systems have different technical principles and their advantages and disadvantages in practical application.

2.1.1 Acoustic Emission Location Technology
Acoustic emission localization technology is a technology that uses acoustic detection sensors to capture sound waves and process the received signals digitally (amplification, filtering, shaping, etc.) to determine the direction and distance of the sound source. Time difference of arrival (TDOA) is a common wireless location technology. TDOA determines the location of sound source by measuring
the arrival time difference of sound waves from the same source collected by three or more acoustic emission sensors. The location accuracy is relatively high [2].

In recent years, there are many kinds of automatic target-reporting systems based on acoustic emission positioning technology, such as quadrilateral array, four-point circular array, eight-point linear array, eight-point circular array, eight-point square array, horizontal double triangular array and so on. Four-dot square array and four-dot circular array are composed of four sensors, which are mainly suitable for small target impact location. Eight-point square array and eight-point circular array are composed of eight sensors, which are also suitable for small target array, but their positioning accuracy is higher than that of four-point array. The double triangle horizontal acoustic positioning system consists of six sensors, six of which are located at the vertex of two equilateral triangles, and two equilateral triangles are symmetrically placed on the midline of the target frame. Double triangle horizontal acoustic positioning system is mainly used to locate the impact point coordinates of large target surface. Target reporting system based on acoustic emission positioning technology has strong environmental adaptability, high integration of components, small size and low price.

2.1.2 Image Processing Technology

Image processing technology is to use the camera to collect the physical target image, get the target image containing bullet holes, find the real bullet impact point in the target image through image processing and recognition technology, and then determine the ring value by the position of the bullet impact point in the target. Image processing technology includes image preprocessing technology, bullet hole recognition technology, system and data statistics management.

With the development of digital image processing technology and automatic target reporting system, many methods of bullet hole recognition have been developed: subtraction based on time series image is more simple and fast; recognition of bullet hole based on common template matching and moment invariant correlation matching of bullet hole further enlarges the detection range and improves robustness; recognition of bullet hole based on fuzzy theory is faster. Fast, accurate results, high practical value; recognition algorithm of bullet holes based on grey-scale characteristics of bullet holes is simpler; recognition method of bullet holes based on image information fusion technology solves the problem of noise and target loop interference [4].

2.1.3 Optical Fiber Coding Technology

Optical fiber coding technology divides the detection field of view of sky screen target into many small sector areas and arranges them into optical fiber coding array. According to the principle of photoelectric conversion, a detection screen capable of calculating the spatial coordinates of the target is formed by optical fiber coding. The optical fiber coding measurement system is composed of optical fiber coding sky screen target, signal processing circuit and computer.

The development of optical fiber coding positioning target is a process of continuous optimization of target accuracy and response speed. It achieves many breakthroughs, such as target surface is not restricted by environment, easy to verify, system structure is simplified, and measurement and determination of multiple shooting modes are supported. Its disadvantage is that the target surface is relatively small, it does not support long-distance testing, and the lens structure is cumbersome, the hardware requirements are high, the fabrication process is complex and the manual test process is added.

2.1.4 Photoelectric Sensing Technology

Photoelectric sensor technology uses photoelectric transceiver devices with high sensitivity, such as light-emitting diodes and light-emitting diodes, to divide the target into matrix meshes. Each small mesh corresponds to an area on the target, and the coordinates of the corresponding points on the target are composed of the number of photoelectric devices in the vertical and horizontal directions. Every time a projectile hits the target, it passes through the light curtain composed of laser beams to get the coordinates of the projectile points.

In recent years, semiconductor light sources and semiconductor photosensitive detectors have been widely used. Target reporting system based on photoelectric sensing technology is becoming more
and more mature, gradually replacing the traditional photoelectric testing method of light curtain area formed by semiconductor lasers, spherical reflectors and photosensitive detectors with lens convergence. At the same time, compared with the existing parallel double-screen target, six-screen precision target and six-screen Sky-screen vertical target technology, it has the advantages of low cost and easy maintenance. The photoelectric automatic target-reporting system based on photoelectric sensor technology has the advantages of fast response and high accuracy, and does not need to change the target frequently. However, it is necessary to install a large number of laser emitter pairs to ensure accuracy, which will inevitably increase the difficulty of installation and power consumption of the system, and the performance of the long-term stable operation of the system will be reduced.

2.2 Research Status of Target Reporting System

The design principle of the existing automatic target-reporting system is various, and the quality and grade of various products are uneven. The following are several target-reporting systems which are widely used at present:

2.2.1 Acousto-Electro Positioning Automatic Target Reporting System

The principle of the automatic target-reporting system is that the shock wave generated by the supersonic projectile acts on the acoustic sensor to generate pulse signals, then converts the pulse signals into electrical signals and analyses them to get the arrival time of the sensors. Then the collision coordinates are calculated according to the mathematical model of TDOA and sensor array. Acousto-electric positioning automatic target-reporting system has relatively high positioning accuracy, realizing environmental independence is not limited to illumination, and can be applied to complex field environment.

2.2.2 Target Reporting System Based on Image Processing Technology

The principle of target reporting system based on image processing technology is that the image acquisition system converts physical target image into digital target image, then the image processing system digitalizes, calculates parameters and transfers the target situation to the database management system, and finally the database management system outputs the results to the computer user interface [7]. The target-reporting system based on image processing technology can avoid the interference between adjacent targets, but its accuracy is relatively low and response speed is slow [8].

2.2.3 Optical Fiber Coding Location and Target Reporting System

The principle of optical fiber coding positioning and target reporting system is to cut the target surface into very small units and install two groups of cameras with different focal lengths (far and near) in parallel to form cross and complementary optical targets. Shorter focal length lenses cover a wide range of targets, and lenses with longer focal length have high resolution, so the coordinates of the impact point can be inferred from both the range and accuracy of detection. The advantage of the system is that the target surface is not limited by space, and its structure is relatively simple compared with other methods. For the statistics of target number, internal trigger is used to trigger, which supports multiple shooting methods. The disadvantage is that the target surface can not be expanded and the hardware requirements are high. Considering the practical application scope and maintenance cost, it is less used.

2.2.4 Photoelectric Sensor Automatic Target Reporting System

The principle of the photoelectric sensor automatic target-reporting system is that the light emitted by two groups of closely arranged light-emitting devices forms a pair of lines, dividing the target into matrix grids, each small grid corresponds to an area on the target, and the coordinates of the corresponding points on the target are composed of the number of photoelectric devices in the vertical and horizontal directions. Every time a projectile hits the target, it passes through the light curtain composed of laser beams, which will inevitably block at least two light rays in a transverse and vertical direction. The pulse of the photosensitive device will change with the change of light and shade, thus obtaining the coordinate of the projectile’s impact point [9]. The system is not restricted by target conditions and environmental factors, so it can make the shooting training process more
smooth, efficient and accurate. However, the cost of high-precision laser diodes is too high to be used in large quantities. Ultimately, they can only make trade-offs in effect and cost, so they are not widely used.

2.2.5 Other target-reporting systems
The principle of double-layer electrode short-circuit sampling system is that when the projectile hits the target surface made of double-layer isolation metal target paper, the metal shell of the projectile has conductive characteristics and forms a loop with the double-layer metal target paper. The electrical signal is converted and processed by the system to form a digital signal so as to realize automatic target reporting. The system is usually not affected by illumination, temperature and electromagnetic wave, but because of the high training cost caused by frequent replacement of target paper, it is difficult to widely use the target-reporting system.

The principle of the electrodes embedded automatic target reporting system is that a two-dimensional grid composed of electrodes is embedded in the interlayer of the target body, and a coordinate system is simulated. When the diameter of the projectile is larger than the interval between the two electrodes in the transverse and longitudinal direction, at least two electrodes will be cut off each time the projectile passes through the target. At this time, the resistance between electrodes with different numbers will change. By measuring these changes, the coordinates of projectiles can be determined, and then the position of the point of contact can be determined, and the number of rings can be determined. The target-reporting system has fast response speed and high target-reporting accuracy.

The existing target-reporting systems are applicable to certain areas because of their respective technical characteristics, but at the same time they have their own defects, which points out the direction for the innovation and development of the target-reporting system in the next step.

3. Research Prospects

With the further development of positioning technology, the future development trend of target-reporting system is as follows:

3.1 Increase the combat adaptability of automatic target-scoring system
The development of miniaturized and portable automatic target-scoring system is still a hot research topic in the future. Further integration of system components and the use of lithium batteries for system power supply can increase its portability and environmental adaptability. The portable automatic target-reporting system makes the army training no longer restricted by the field and equipment, and has greater practical significance for the field training of the army.

3.2 Further Improving Capture Response of Projectile
Most of the existing automatic target-reporting systems focus on single bullet hole recognition in the case of point-firing. With the continuous development of light weapons and equipment, the acceleration of firing speed and the phenomena of continuous firing, heavy holes and miss-distance in training and actual combat, the automatic target-scoring system is required to have further innovation in the acquisition response of projectiles and the algorithm of hole detection, so as to make the system more widely applicable to the target.

3.3 In-depth study of more intelligent automatic target-reporting system
At present, the design of automatic target-scoring system is limited to the accuracy of identifying bullet holes. The increasingly mature intelligent technology makes it possible to develop more intelligent and humane automatic target-scoring system. The next step is to expand the functions of automatic target-changing, voice target-scoring, guiding target-scoring, and teaching and training of the target-scoring system, so as to make the auxiliary functions of the target-scoring system more diverse.
3.4 Automatic Target Reporting System Supporting Rich Data Applications

During the firing process of live ammunition, the analysis and application of firing data are realized by means of information query, statistical analysis and intelligent management. For example, the distribution of impact points can be analyzed to achieve intelligent evaluation of shooting performance, and provide data reference for coaches’ targeted guidance.

4. Summary

The development of target-scoring system is accompanied by the continuous development of science and technology. After analyzing the advantages and disadvantages of the main positioning technology at home and abroad and the existing automatic target-scoring system, the future trend of target-scoring system towards intelligence, miniaturization, adaptability and portability is prospected.

References