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Array LED Light Source Used with CCD Optical Target

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Abstract

There are currently no test systems which can work in indoor environment of large screen set target. According to CCD optical target applying outdoor, the constitute of the light is analyzed, the method that the light source is designed to provide background illumination for CCD optical target using specific wavelengths light emitting diode is proposed. According to the CCD responsivity, the light source of CCD optical target is designed with wavelength of 680nm LED. Through the simulation

tests, the distribution of luminous intensity of LED array is analyzed. The structural parameters of the light source is designed, the uniformity of the light source is enhanced further using double-sided frosted glass. Experiment shows that the effect of CCD optical target using light source designed in this paper is better then using natural light. The target measuring requirements are meted. The scope of application of CCD optical target is expanded.
Key words: CCD OPTICAL TARGET, COORDINATE OF TARGET, LIGHT SOURCE, LED

1. Introduction

CCD optical target is mainly applied in exterior ballistic coordinate of target and measurement of shooting concentration, it usually used in outdoor work[1,2], working with natural light as light source, because of its unique advantages, in recent years CCD optical target has been more widely studied and applied.

CCD optical Target is mainly applied in exterior ballistic coordinate of target and the test of shooting concentration, and usually used in outdoor work, working with natural light as light source, because of its unique advantages, in recent years CCD optical target has been more widely studied and applied. At present, the target measuring systems for the indoor uses the long radio structure design of array photoelectric receiving devices and array luminous light source, need not optical lenses, its advantage is low cost. But due to the relatively complicated structure, and the testing target surface is smaller ,usually not more than 2m x 2m target surface. In order to increase its target surface[3,4,5], we need to increase the number of photoelectric array receiving device and the length of the array light source, increasing the structural frame, this design is more cumbersome and photoelectric receiving part and luminous part are more difficult to align, thus seriously affects the measurement precision, resulting in the poor engineering[6].

Based on the application of CCD optical target in outdoor has the features of a large field of view and high testing precision, introducing indoor measurement, the steady background light source must be offered so that CCD optical target can be applied. Based on CCD detection characteristics, an array LED light source with CCD optical target is analyzed in this paper.

2. The formation of CCD optical target light curtain

CCD optical target is used in indoor, as background lighting source, which is formed by the light-emitting diode, shooting CCD camera[7]. When the projectile passes between the light source and CCD optical target, the light from light source is kept out by the projectile, then shadow image is formed the CCD image plane, so as to realize the capture of CCD optical target to the projectile, the formation of CCD optical target screens shown in figure 1. The luminous intensity is more stable and uniform in that the diode making use of DC power [8].

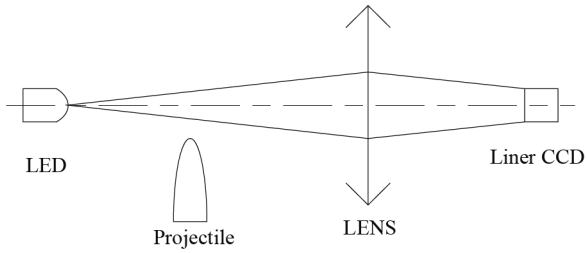


Figure 1. CCD optical target screens formation schematic

3. The formation of CCD optical target light curtain

3.1 CCD spectral response

In order to meet light source used of CCD optical target in indoor, we need to know the characteristics of CCD spectral response. The pixel resolution of the target is 2048, pixel size of linear array CCD is 10μm. The spectral response is shown in figure 2. From the graph we can see that light sensitivity of CCD wavelength between 760nm and 680nm is highest[9].

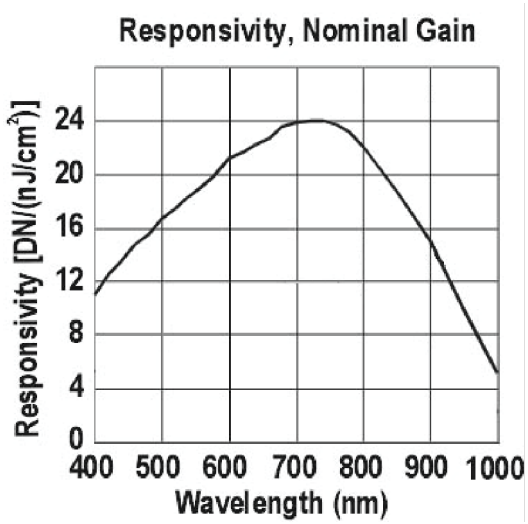


Figure 2. CCD spectral response

3.2 The choice of light-emitting devices

Light-emitting devices are important component of CCD optical target indoor light source, it demands to meet enough brightness, and has some advantages

which are a long life, low power consumption and small size. Common devices used with halogen light, xenon light, laser light source, etc[10]. Taking into account the size of light source, power, stability and other factors, Using high brightness light-emitting diode array is more suitable for practical application. LED manufacturing technology has reached a mature. Furthermore, LED exit light with a certain angle, the emitting angles of different type LED are not the same, at the same time LED appearance are also different[11].

LED can be seen as an expanded surface light source. That is to say, Brightness of LED light in all directions are equal in the range of solid angle. According to Lambert's law, on the vertical illuminating surface of LED, luminous intensity in all directions are:

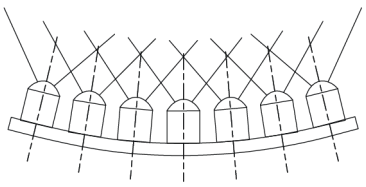
$$I_\theta = I_0 \cos\theta \tag{1}$$

According to CCD spectral characteristics and the actual requirements of light source, we select a wavelength which is 680nm, divergence angle which is 80 °, blunt-nosed diameter of light-emitting diode is 6mm.

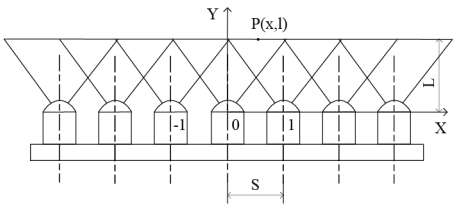
4. Designing of Large Area Light Source

4.1 Designing of the overall structure

The structure of LED array light source are mainly two categories, including arc and straight, as shown in figure 3.



(a) arc-shaped light source



(b) Straight-shaped light source

Figure 3. Structure of line light source

Considering the uniformity of luminous intensity, Arc-shaped which could base on each distribution angular of LED luminous intensity to design arc curvature in defined space curve and come up to uniform light intensity. However, taking into account the design of the installation site cross-section of interior space of the light source is 10m × 10m, arc-shaped light source has many disadvantages, such as complexity installation, affecting the test target area of CCD optical target, and poor security weaknesses, so we can only use straight linear structure.

Light source which we have designed is applied in CCD optical target, the image acquisition experiments of CCD image shown in figure 4.

Figure 4. LED direct shooting CCD image acquisition

We can see from the graph that CCD image acquisition appear bright and dark stripes, which is very adverse for using of target (Dark stripe may inundate projectile signal and thus seriously affect the projectile capture and later image processing). The analysis found that bright stripe, which is from LED, has formed on the CCD imaging a surface directly. The dark stripe is caused by the light from adjacent LED array out of the gap between the images. In view of this transforming structure of the light source, double-sided ground glass was installed before light source, because ground glass has the diffuse effect, so diode glow shines ground glass, forming a uniform diffuse surface, and further enhancing homogenization of the luminous intensity of light source. The structure parameters of light source in L and S directly affect the luminous intensity and uniformity of light-emitting diode to the ground glass surface. Defined as follows:

As shown in figure 3(b), at a distance of diode luminous point L is any point on straight line *P(x,L)*, *LED(-1)*, *LED(0)*, *LED(1)* the intensity respectively as:

$$I_{P-1} = I_0 \frac{L}{\sqrt{L^2 + (S+x)^2}} \tag{2}$$

$$I_{P0} = I_0 \frac{L}{\sqrt{L^2 + x^2}} \tag{3}$$

$$I_{P1} = I_0 \frac{L}{\sqrt{L^2 + (S-x)^2}} \tag{4}$$

LED(N) Contribution to the light intensity as:

$$I_{PN} = I_0 \frac{L}{\sqrt{L^2 + (NS+Fx)^2}} \begin{cases} F=-1, N<0 \\ F=1, N \geq 0 \end{cases} \tag{5}$$

In the formula, *N* is an integer.

Because the light-emitting diodes are independent

light sources, given the independent light of different LED emitting, so superposed intensity is the sum of diode light intensity. The point of *P(x,L)* light intensity:

$$I_P = \sum \frac{L}{\sqrt{L^2 + (NS + Fx)^2}} \quad (6)$$

L and *S* are variables on luminous intensity distribution of light source, the simulation was shown in figure 5.

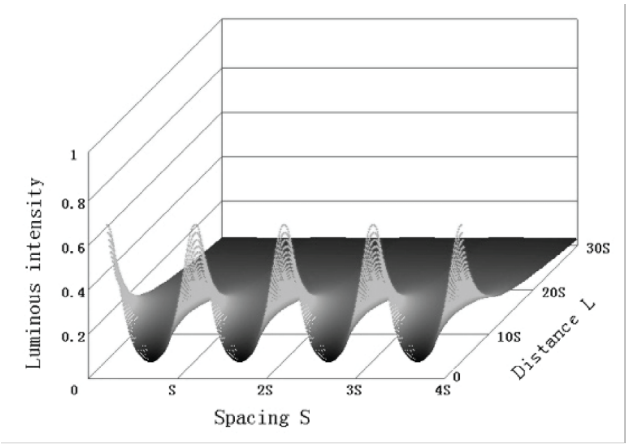


Figure 5. Distribution of luminous intensity

We can see from the diagram, the greater *L/S* is more uniform the light intensity of ground glass surface, but *S* is constrained by size of the LED itself, the minimum can be *S=6mm*, if you want to increase it you must increase *L*, not only light intensity of light source will decrease, but also make external dimension of light source become too large, affect the applicability of the light source project.

Through many experiments analyzing the distance *L* is 80mm between ground glass and circuit board, the uniformity of light source could meet the requirements of the background illumination of CCD optical target, in order to facilitate CCD optical target alignment with the light source, the width light source designed is 50mm, the overall structure shown in figure 6 .

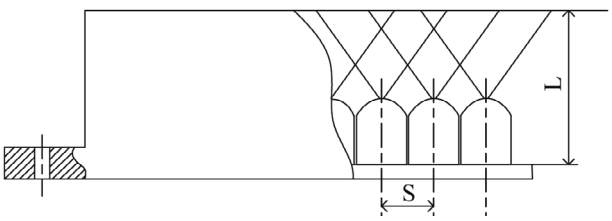


Figure 6. The overall structure schematic diagram of light source

4.2 Driver circuit

According to the operating principle of CCD optical target, the light intensity of light source does not have too much stability requirements in time, but only light source has good uniformity requirements in space, so drive circuit only adopts simple constant voltage source, Adding to filter circuit can meet the requirements.

5. Experiment and Analysis

A part of the array LED light source is shown in figure 7, forming 8m × 8m testing target surface together with the CCD optical target. Testing experiment of 7.62mm rifle shooting process in indoor, image collected of the projectile is shown in figure 8.

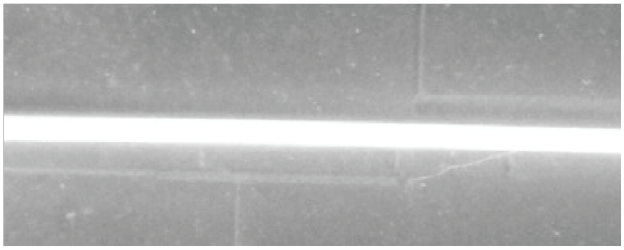


Figure 7. A part of the array LED light source

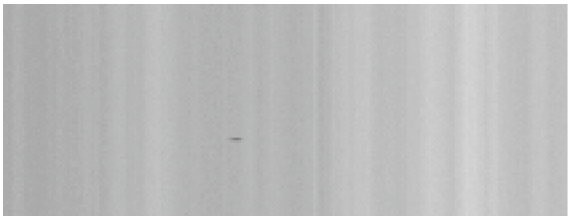


Figure 8. 7.62mm rifle projectile image collected indoor

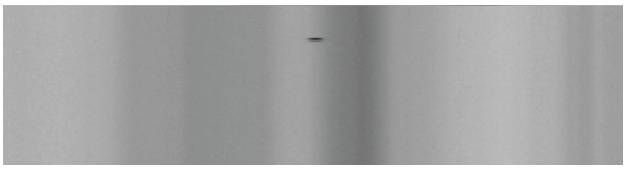


Figure 9. 35mm artillery projectile image collected outdoor

We can see from figure 8, the indoor image collected of projectile with good contrast, the process can accurately identify the projectile, calculating the coordinate of projectile over the target. Comparing with outdoor images collect of 35mm artillery projectile in figure 9 shown, background formed by indoor light source is better than background of outdoor natural light (the changing background brightness caused by clouds in the sky), and its brightness is stable, suffering environmental less impact, More advantages to the extraction and calculation of post-shot projectile image. Through reading compared with the target coordinate after multiple shooting, projectile capture rate is 100%, and measurement error is less than 10mm, those parameters fully meet the test requirements. From the experimental results, the light source designed can meet needs of the interior large area CCD optical target.

6. Conclusions

For the existing outdoor CCD optical target, ac-

cording to the spectral characteristics of CCD, we adopt 680nm high brightness infrared LED array to design the light source, the design performance of light source is stable, low power consumption and can supply with AC-DC power, through the simulation analysis of luminous intensity and experiments to determine the overall structure parameters of light source, the diffuse effect of ground glass further enhances the uniformity of light source, live ammunition tests show that the light source designed which can ensure the projectile capture rate of system and the accurate coordinate of the projectile. To meet measurement needs of indoor CCD optical target, and extend the application range of CCD optical target.

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