# CCD Mosaic of Big Target Surface Vertical Target

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Abstract
Through the analysis of the principle of intersection measurement of two-CCD, a multi-field CCD mosaic method to increase the detection is proposed in this paper, which has solved the problems that a large target surface target measuring is in a small space. According to the CCD intersection measurement principle, which has divided the target surface into four regions effectively, a multi-CCD light target pellet coordinates has been established to calculate the data model. Analysis of mosaicing CCD of multi-measurement system measurement error shows that the sources of error are similar to the double CCD intersection measuring system. Analyzing of the linear array CCD intersection measuring target, measurement error is caused due to the overlapping CCD detection target surface.
Key words: CCD VERTICAL TARGET, COORDINATE MEASURING, PROJECTILE, THE MEASUREMENT ERROR.

## 1. Introduction

As a non-contact optical measuring technology, CCD optical target coordinate measurement in the moving target space has a great advantage in application in recent years and has been widely used[1,2].

CCD optical target structure and properties of two commonly used linear array CCD camera is exactly the same on both sides of the trajectory relative arrangement of the camera optical axis with the ground with a certain angle, field of view of two overlapping CCD detection CCD optical target area is the target of effective test surface, taking into account of the distortion of the optical lens system would seriously affect the measurement accuracy, the general detection of each CCD field of view angle is less than 45 °, which makes the formation of a certain size to test the target surface is required between the two CCD greater distance, and bull's-eye is relatively high[3]. This narrow channel space for the target (such as indoor shooting lane, etc.), the effective requirements of relatively large target surface and a lower trajectory shot is very unfavorable circumstances, and sometimes it cannot satisfy the application [4].

In response, this paper presents a multiple based on the intersection of CCD mosaic field measurement and analysis of their mathematical model, the analysis shows that the method can maintain the precision of the system in the premise, in a small space set targets to achieve a large measure target surface, extends the scope of application of CCD optical target.

## 2. Dual CCD intersection measuring

### 2.1 Measuring principle

As shown in figure 1, linear array CCD cameras are arranged in the CL and CR both sides of the target channel, CL DOB field of view the formation of fan-shaped detection area, CR formation AO'C fan-shaped field of view of detection area, the two fan-shaped region of space in the same plane intersection of the maximum square area for the ABCD, the area is the system effective measurement target surface (shaded area); and the target surface and the horizontal plane are perpendicular to the trajectory[5,6].

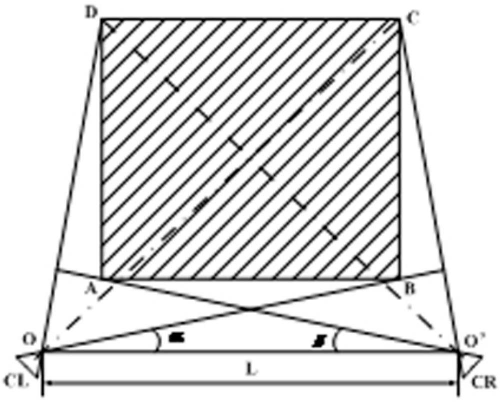


**Figure 1.** Principle of linear CCD intersection test

During the working, CL and CR of the linear array CCD camera gather projectile image at the same time, when the projectile passes through the target surface, blocking the formation of the background light, and then form the shadow image on CCD image plane, the image pixel coordinates of the projectile will obtain after the image processing, connect with internal parameters and layout parameters of CL and CR of CCD camera, and calculate the projectile target coordinates.

### 2.2 Calculate the Coordinate formula

Dual CCD intersection measuring system calculation principles of the projectile over the target coordinates shown in figure 2[7].

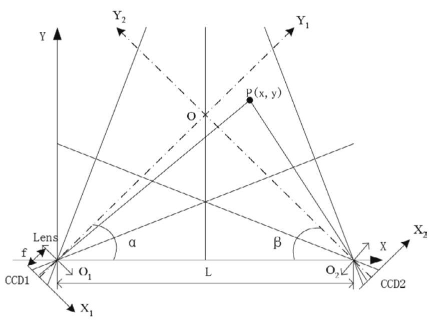


**Figure 2.** The calculation of the projectile over the target coordinates schematic

Coordinate system to establish that the origin of coordinates, according to the triangular relationship between the figures can be

$$\frac{y}{x} = \tan(\alpha - \arctan\frac{x_1}{f}) \tag{1}$$

$$\frac{y}{L-x} = \tan(\beta - \arctan\frac{x_2}{f}) \tag{2}$$

$$x = \frac{L \times \tan\left[\alpha - \arctan(\frac{A_1}{f})\right]}{\tan\left[\beta - \arctan(\frac{A_2}{f})\right] - \tan\left[\alpha - \arctan(\frac{A_1}{f})\right]} \tag{3}$$

$$y = \frac{L \times \tan\left[\beta - \arctan(\frac{A_2}{f})\right] \times \tan\left[\alpha - \arctan(\frac{A_1}{f})\right]}{\tan\left[\beta - \arctan(\frac{A_2}{f})\right] - \tan\left[\alpha - \arctan(\frac{A_1}{f})\right]} \tag{4}$$

Where, f is the lens focal length, L is the distance between the CL and CR of the CCD camera, $\alpha$ and $\beta$ CL are the angle which are between the CL and the CR for the CCD camera horizontal axis respectively, and are shot in the CL and CR CCD camera pixel coordinates of image plane .

## 3. Multi-CCD intersection measurement

### 3.1 Measuring principle

According to the CCD measurement principle based on the intersection, the system effectively test the target surface and the line array CCD camera field of view angle and the distance between the CL and CR, and when the test constitutes a dual CCD system, taking into account the distortion of the optical lens will seriously affect system accuracy[8], the general field CCD angle of detection of not more than 45 °, and in confined spaces (such as indoor shooting lane) used, CL, and CR limit the distance between the received integrated projectile diameter size and the capture of the projectile and identification of problems can not be achieved with double CCD large target surface intersection tests.

Based on the above analysis, in the small space to achieve great test target surface, can only increase the CL and CR in the detection field of view, the reference lens distortion, this paper proposed a multi-field CCD mosaic methods to increase the CL and CR detection field of view in order to achieve a large space in a small test target surface[9].

### 3.2 Coordinate formula

Intersection of four CCD measurement system as an example, the calculation of the projectile over the target coordinates of the principle is shown in figure 3.

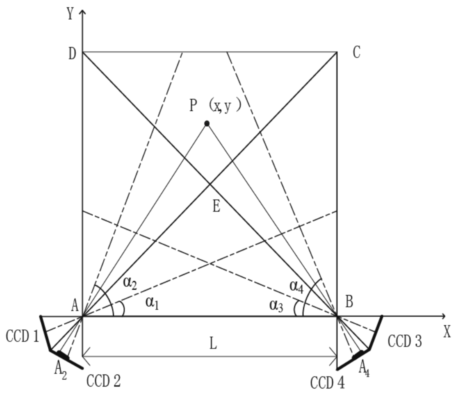


**Figure 3.** The calculation of the projectile over the target coordinates Schematic

When the projectile from in ABE area of Figure 3 through the target surface, the area covered by the detection view of CCD1 and CCD3, when projectile from this area through the target surface, will be in CCD1 and CCD3 capture images, through the special purpose image processing software to extract image coordinates projectile respectively $A_1$ and $A_3$, A is the origin of coordinates, the measurement principle of the intersection measuring and the calculation of the projectile over the target coordinates are:

$$x=\frac{L\times\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]}{\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]-\tan\left[\alpha_1-\arctan(\frac{A_1}{f})\right]} \quad (5)$$

$$y=\frac{L\times\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]\times\tan\left[\alpha_1-\arctan(\frac{A_1}{f})\right]}{\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]-\tan\left[\alpha_1-\arctan(\frac{A_1}{f})\right]} \quad (6)$$

In a similar way, when the projectile from ADE area through the target surface, the calculation of the projectile over the target coordinates are:

$$x=\frac{L\times\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]}{\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]-\tan\left[\alpha_2-\arctan(\frac{A_2}{f})\right]} \quad (7)$$

$$y=\frac{L\times\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]\times\tan\left[\alpha_2-\arctan(\frac{A_2}{f})\right]}{\tan\left[\alpha_3-\arctan(\frac{A_3}{f})\right]-\tan\left[\alpha_2-\arctan(\frac{A_2}{f})\right]} \quad (8)$$

When the projectile from CDE area through the target surface, the calculation of the projectile over the target coordinates are:

$$x=\frac{L\times\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]}{\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]-\tan\left[\alpha_2-\arctan(\frac{A_2}{f})\right]} \quad (9)$$

$$y=\frac{L\times\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]\times\tan\left[\alpha_2-\arctan(\frac{A_2}{f})\right]}{\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]-\tan\left[\alpha_2-\arctan(\frac{A_2}{f})\right]} \quad (10)$$

When the projectile from BCE area through the target surface, the calculation of the projectile over the target coordinates are:

$$x=\frac{L\times\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]}{\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]-\tan\left[\alpha_1-\arctan(\frac{A_1}{f})\right]} \quad (11)$$

$$y=\frac{L\times\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]\times\tan\left[\alpha_1-\arctan(\frac{A_1}{f})\right]}{\tan\left[\alpha_4-\arctan(\frac{A_4}{f})\right]-\tan\left[\alpha_1-\arctan(\frac{A_1}{f})\right]} \quad (12)$$

Where $f$ is the lens focal length, $L$ is the distance between the two CCD cameras, and $\alpha_2, \alpha_2, \alpha_3, A_1$ are CCD1, CCD2, CCD3, CCD4 the angle between the horizontal axis, and $A_1, A_4, A_4, A_4$ are shot in the CCD1 or CCD2 or CCD3 or CCD4 image plane pixel coordinates.

If $S(i,j)\{i=1,2; j=3,4\}$ indicate that system test target surface, you can make the following definition:

$S(2,4)$ is ABE area;

$S(2,4)$ is ADE area;

$S(2,4)$ is BCE area;

$S(2,4)$ is CDE area.

Then when any area $S(i,j)\{i=1,2; j=3,4\}$ across from the time the projectile, the projectile over the target coordinates are calculated as:

$$x=\frac{L\times\tan\left[\alpha_j-\arctan(\frac{A_j}{f})\right]}{\tan\left[\alpha_j-\arctan(\frac{A_j}{f})\right]-\tan\left[\alpha_i-\arctan(\frac{A_i}{f})\right]} \quad (13)$$

$$y=\frac{L\times\tan\left[\alpha_j-\arctan(\frac{A_j}{f})\right]\times\tan\left[\alpha_i-\arctan(\frac{A_i}{f})\right]}{\tan\left[\alpha_j-\arctan(\frac{A_j}{f})\right]-\tan\left[\alpha_i-\arctan(\frac{A_i}{f})\right]} \quad (14)$$

### 4. Multi-measurement error of CCD intersection measurement

CCD intersection measuring system based on multi-projectile over the target coordinate calculation shows that the principle, mathematical model of error analysis and dual-CCD of the same measurement system error[10]. The structure analysis from multiple CCD, its agencies is more complicated, which makes the design process and site layout more difficult, very difficult to detect CCD field of view completely coplanar, resulting in the target surface not overlapping, causing the error not overlapping the target surface [11, 12]. Target surface do not overlap error mainly generated by the following three basic reasons, namely:

1) CCD detection target surface parallel to each other, and with a certain distance, shown in figure 4.

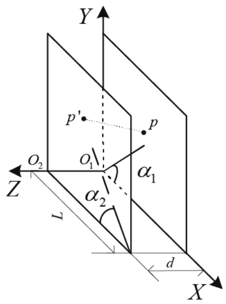


**Figure 4.** CCD detection target surface parallel to the non-overlapping

2) CCD detection target surface exists between the angle in the horizontal direction, as shown in figure 5.

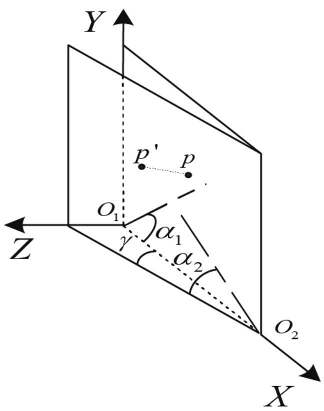


**Figure 5.** CCD detection of the horizontal angle of the target surface do not overlap there

3) CCD2 detection target surface exists between the angle in the vertical direction, shown in figure 6.

When the projectile over the target surface perpendicular to the test target, by the CCD detection target surface parallel to the non-overlapping measurement error had no effect on the system; by the existence of CCD detection level of the target surface do not overlap angle and vertical angle measurement error of the system are small.

When the projectile over the target surface is not

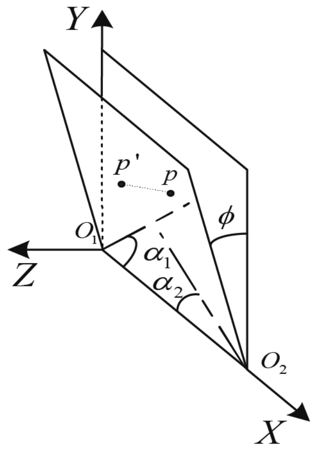


**Figure 6.** CCD detection of vertical angle of the target surface do not overlap

perpendicular to the test target, by the CCD and the CCD detection target surface parallel to the existing level of detection of the angle between the target surface caused by the target surface not overleaping on the impact of measurement error is small and with too little to the target location; by the CCD detection of vertical angle between the target surface caused by the target surface not overleaping on the measurement error is relatively large; and with the location of the projectile over the target.

## 5. Conclusion

Testing of target channel for small space (such as indoor shooting lane) vertical target coordinate, according to the traditional two-CCD intersection measuring principle, a more than one CCD field of view based on the intersection of stitching measurement method is presented, and establish the computational mathematics model of projectile over the target coordinates. The measurement error analysis shows that with the method guarantees vertical target coordinate measurement accuracy of the premise, a good solution in a small space to achieve a large target surface vertical target coordinate measurement problem, while expanding the range of CCD intersection measuring system applications.

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# A PTV Method Based on SIFT Feature Points Matching for Velocimetry Measurement

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