# Design of Ground Target Based on RedEdge MX-Dual Multispectral Camera

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**Abstract.** Ground target plays an indispensable role in UAV near-earth remote sensing geometric positioning, geographic registration, correction and improvement of remote sensing image accuracy and accuracy. Traditional ground targets are markers with distinct features, shapes and textures, and their dimensions are usually fixed. The UAV can provide high-resolution multi-spectral data with multi-spectral camera, so the target resolution will change as the UAV height increases and the camera band increases, in some bands of the multi-spectral camera, there will be non-response, which will affect the accuracy of target recognition and positioning. Based on the color, material, size and shape of target, a set of targets suitable for target recognition and location of multi-spectral camera is designed in this paper. In order to judge whether the target performance meets the requirements, this paper verifies the positioning accuracy of the target and its response in each channel of the camera. It is proved that the target plane error is about 10mm at 20 ~ 100m altitude, and the height error is about 40mm, and it can respond in ten channels, it provides experience and ideas for the design and development of multi-spectral camera targets.

**Keywords:** Drones; RedEdge MX-dual Multispectral Camera; Target Design.

## 1. Introduction

Ground target plays a key role in UAV near-earth remote sensing. By establishing the relationship between ground coordinates and image pixels, ground surface features can be accurately measured and analyzed. Although the ground target has been fully developed, there are still some deficiencies in the design. The size of the traditional target is fixed in the design, so the selection of the image control point will be affected by the ground resolution of the camera, therefore, the relationship between target mark size and altitude and ground resolution should be considered in the design. In addition, the traditional ground target design is mainly for color camera, for multi-spectral camera, the target will not respond in part of the band, so we need to consider the optical characteristics of the target.

To sum up, this article refers to the physical characteristics of traditional ground target design and the optical characteristics of remote sensing radiation correction target design, and fully considers the flexible maneuverability of multi-spectral camera and UAV, taking RedEdge MX-dual multi-spectral camera as an example, a set of targets suitable for multi-spectral camera's target recognition and localization were designed.

## 2. Target Design Basis

This article improves the target from four aspects: size, color, material, and shape. The basis for improvement is as follows.

### 2.1 Design Basis for Logo Size

If the imaging size is too small, it will affect the recognition of image points due to the insufficient number of pixels occupied; If the imaging size is too large, it will lead to a decrease in the positioning accuracy of the image points. Therefore, this article needs to adjust the size of the logo to flexibly respond to ground resolution changes caused by different altitudes.

### 2.2 Design Basis for Target Color

Although traditional targets have bright colors that are beneficial for recognition, they are not suitable for multispectral cameras, as the same color may result in different response results in different channels of the camera. Therefore, it is necessary to design the color so that it can respond in all channels of a multispectral camera.

### 2.3 Design Basis for Target Color

The requirements of remote sensing satellite observation standards for standard plates are to have low reflectivity and anisotropy [4]. Different materials have different reflectivity, so in order to meet the specification requirements, it is necessary to consider the target material. The current national standards stipulate that low altitude photogrammetry requires the target to meet the following requirements: the image of the control point in the photo should be clear and easy to distinguish [1], so it is necessary to choose a shape with obvious features as the symbol. Therefore, it is necessary to design the target material and logo shape.

## 3. Production of Targets

### 3.1 Selection of Target Mark Size

3.1.1 Target logo size design

In order to flexibly respond to changes in ground resolution caused by altitude, this article calculates the ground resolution of each altitude and designs the target based on the ground resolution. The target adopts the same shape, material, and color, with a target size of 60 × 60cm, the internal logo of the target is circular, and the material is low-cost paper. The size design of the logo is shown in Table 1.

Table 1. Target Logo Size Design

| Flight Height (m) | Sign Name | Ground Resolution (mm) | Flag Size Setting (mm) | Photography Scale |
|---|---|---|---|---|
| 20 | Target 1 | 13 | 19.5 | 3703.70370 |
| 30 | Target 2 | 20 | 30 | 5555.56 |
| 40 | Target 3 | 26.7 | 40.5 | 7407.407 |
| 50 | Target 4 | 33 | 49.5 | 9259.259 |
| 60 | Target 5 | 40 | 60 | 11111.11 |
| 70 | Target 6 | 46.7 | 70.5 | 12962.96 |
| 80 | Target 7 | 53.3 | 80.5 | 14814.81 |
| 90 | Target 8 | 60 | 90 | 16666.67 |
| 100 | Target 9 | 67 | 100.5 | 18518.51852 |

3.1.2 Target Mark Size Selection

The logo design is compared between 1.5 to 3 pixels. By using Agisoft PhotoScan to calculate three-dimensional coordinates, the mean square error calculation results for different sign sizes are shown in Figure 1. It can be seen that the sign size design with a ground resolution of 1.5 times better results. Therefore, the final design of the logo size is 1.5 times the ground resolution.

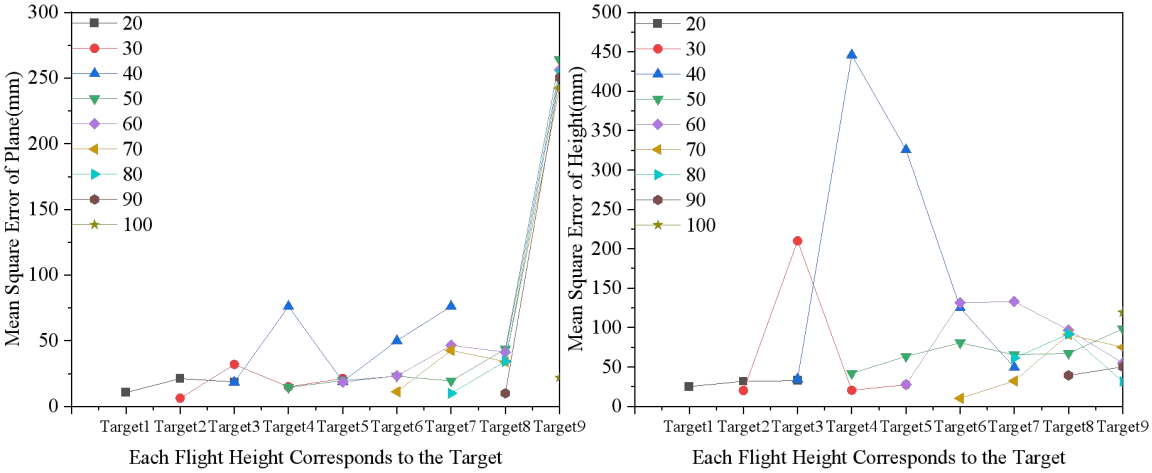


Fig. 1 Mean Square Error of Each Altitude Selection Targets at Altitude of 20-100m; Mean Square Error of Elevation for Each Altitude Selection Targets at Altitude of 20-100m

### 3.2 Selection of Target Color

3.2.1 Target Color Design

The color design adds three colors: red, white, and black, to the six colors of orange, yellow, green, cyan, blue, and purple in the first section. Due to the different reflectivity of different materials [5], paper with the same material as the first section was selected to make the target.

3.2.2 Target Color Selection

The response of the nine colors at 20 m altitude is shown in Figure 2. From the figure, it can be seen that in the visible light band, except for black and white, other colors have poor response in certain channels. Therefore, the target color design is black and white, with black as the target background color and white as the internal color of the logo.

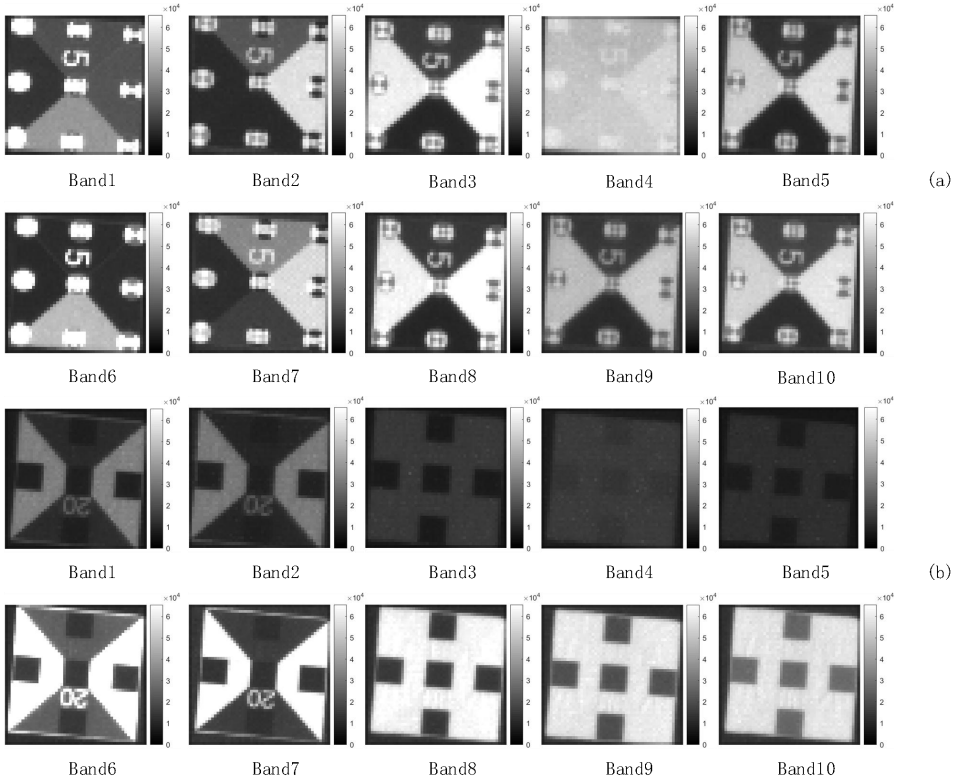


Fig. 2 (a) Color Rendering of Orange, Yellow, Green, Cyan, Blue, and Purple in Ten Bands; (b) Color Rendering of Red, White, and Black in Ten Bands

### 3.3 Selection of Target Material

3.3.1 Target Material Design

The design standard of the material is: the target has low reflectivity and anisotropy, and is not easily affected by the environment [4]. The raw material of leather is PU leather, which has the characteristics of good Lambertian properties, flat spectral reflectance, and good spatial uniformity [3]. The raw materials for both plastic film and floor tile surfaces are plastic films, with the difference being that the former is a light film with a smooth surface [8]; The latter is a twill film, which has the characteristics of uneven surface and good visual effect [7]. The raw material of paper is fiber, which has the characteristics of rough surface and low cost [2]. The raw material of the fabric is polyester, which is commonly used for surveying traditional targets [6]. The substrate is selected as KT board, as this material has a flat surface, lower cost, and lighter weight [9]. In summary, the surface materials of the target were selected from five types: leather, fabric, paper, smooth surface, and floor sticker for comparison. This section improves the target based on the previous two sections. The shape of the target logo is still circular, and the five materials mentioned above are selected for comparison.

3.3.2 Target Material Selection

The drone flew at an altitude of 20m for filming. Firstly, radiometric correction is performed on the drone image, and then the reflectance coefficient of each pixel in the corrected image is calculated using a diffuse reflection plate to obtain the reflectance image. Then analyze the anisotropy of the five materials by determining their reflectivity changes. The greater the change in reflectivity, the greater the anisotropy; On the contrary, the smaller the anisotropy. The average reflectance curves of five materials and the reflectance changes of ten channels at different angles are shown in Figures 3 and 4. Overall, within the ten channels, the reflectivity variation range of leather and floor tiles is relatively small, while other materials have a larger reflectivity variation range in different channels. However, the floor tiles are greatly affected by temperature, and deformation and bending can occur when the temperature is too high or too low. The leather material has the characteristics of being less susceptible to deformation caused by environmental temperature and being easy to carry. In summary, we ultimately chose leather as the surface material of the target.

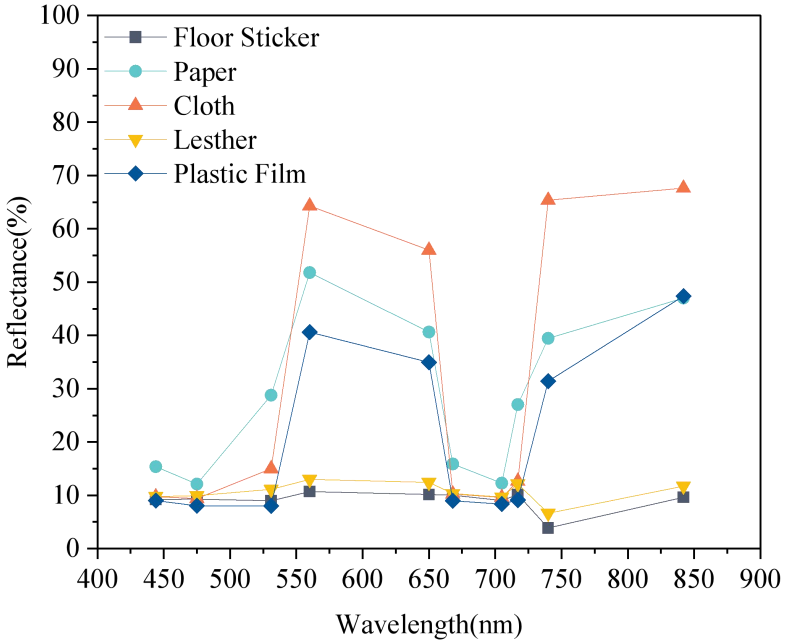


Fig. 3 Average Reflectivity Curve of Various Materials

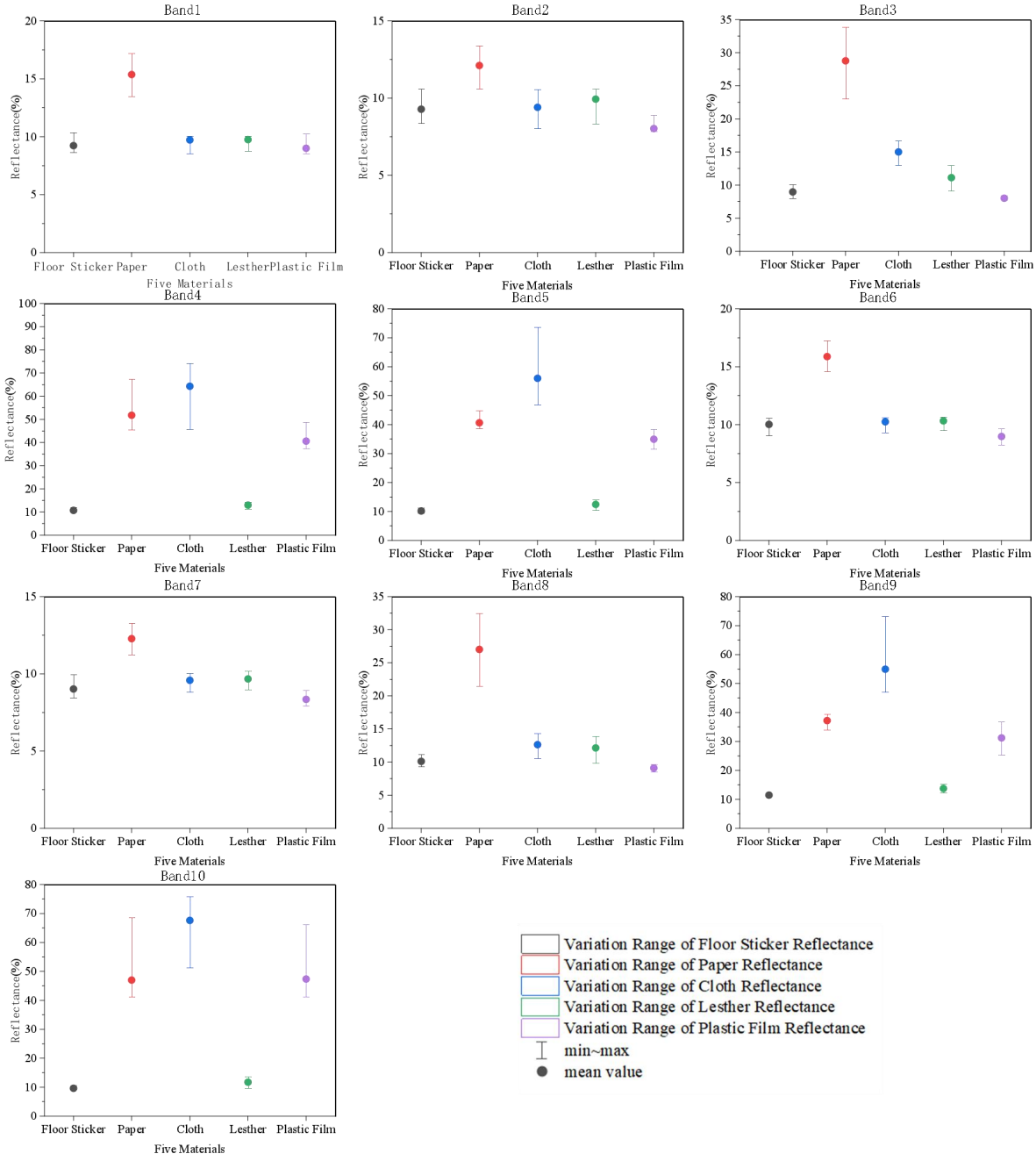


Fig. 4 Changes in Reflectivity of Ten Bands at Different Angles and Materials

## 3.4 Selection of Target Mark Shape

3.4.1 Target Shape Design

The target must choose a shape that is easy to handle and determine coordinate points as feature points, such as the center of a circle, the vertex of a block, etc. Therefore, the shape has been designed to compare square and circular shapes, and the target size has been expanded to 80 × 80cm, the distance between the signs is 210mm, and the center of the circle is represented by a circle with a diameter of 2mm.

3.4.2 Target Shape Selection

With the continuous progress of technology, feature point extraction is currently more inclined towards automatic extraction. Therefore, this section implements automatic extraction of image point coordinates through programming. Due to the high accuracy of manually extracted coordinate calculation results, the manually extracted image point coordinates are used as the original

coordinates for comparison. The error in image center extraction is shown in Figure 5. After verification, the mean square error of the circular marker is relatively small, so the final shape of the target marker is circular.

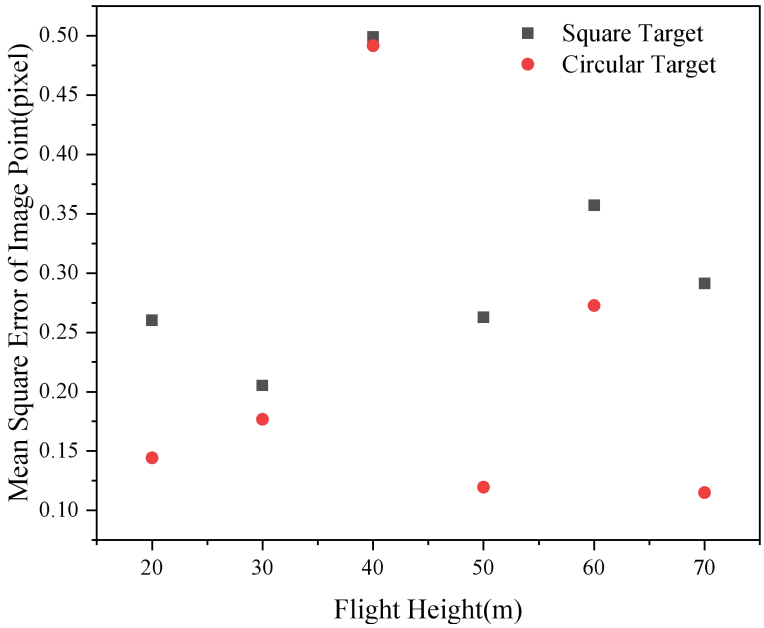


Fig. 5 Mean Square Error of Two Shapes at Different Altitudes

In summary, the final design results of the target in this article are as follows and the design situation is shown in the figure 6:

1) Target size is 80 × 80cm, the size of the sign is 1.5 times the ground resolution, and the distance between the signs is 210mm. The center of the circle is represented by a circle with a diameter of 2mm;

2) The target color is black and white, with black being the background color of the target and the color of the center of the circle, and white being the color of the logo;

3) The target is made of leather material;

4) The shape of the logo is circular.

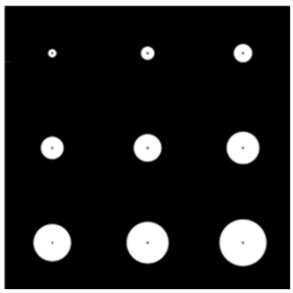

Fig. 6 Final Design Result of the Target

## 4. Summary Target Performance Verification

In order to verify the performance of the target, this section will uniformly deploy the final designed target in the research area. The drone flies at an altitude of 20-100m for shooting, with consistent parameter settings and strict RTK lofting. A total of 8 targets were laid and 4 were used as verification points for accuracy verification. Calculate the three-dimensional coordinates of the target using Agisoft PhotoScan software. The results of the mean square error of each elevation plane and elevation in the ten channels are shown in Figure 7. After verification, the mean square error of each elevation plane in each channel is about 10mm, and the mean square error of elevation is about 40mm, which meets national standards and can be widely used [10-13].

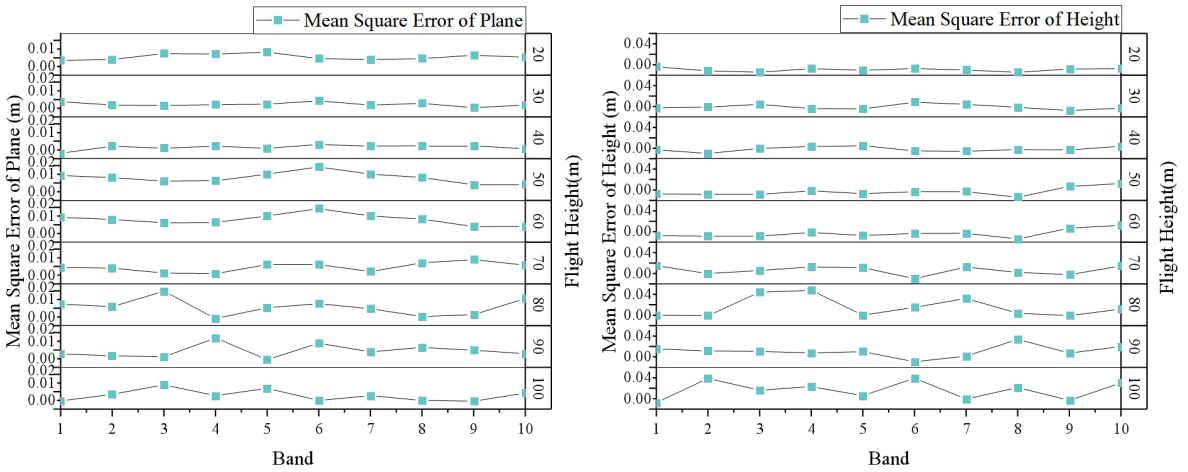


Fig. 7 Mean Square Error of Each Altitude in 10 Bands

## 5. Conclusion

This article proposes a target suitable for the RedEdge MX-Dual multispectral camera for target recognition and positioning. The target is designed from four aspects: internal marker size, color, material, and shape, and evaluation methods are provided. Based on the experimental results of this article, the conclusion is as follows:

1) The size of the logo can be flexibly designed based on the ground resolution of sensors at different altitudes to ensure that the size corresponds to the altitude. This article verifies the accuracy of three-dimensional coordinates calculated by selecting different sizes of signs to determine which size of sign design is better. Through precision verification, it was ultimately decided to design the size to be 1.5 times the ground resolution corresponding to the altitude.

2) Color discrimination is designed based on its response in each channel of the multispectral camera, ensuring that all ten channels can recognize the target. By comparing the response of different colors in ten channels, the target color was ultimately designed as black and white, with black as the background color and white as the small logo.

3) The selection of materials needs to consider anisotropy and reflectivity, and the requirement for anisotropy is that the fluctuation of material reflectivity is less affected by angle changes. Based on the reflectivity and changes of the five materials in this article, it is believed that leather material is the best.

4) The shape of the logo is determined based on the accuracy of extracting pixel coordinates. Compared to the size of the mean square error of the image point, after calculation, the mean square error of a circle is relatively small, so the shape is chosen as a circle.

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