Design of LED grain image recognition and positioning system

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Abstract. LED grain image recognition and location technology is an important technology in LED grain manufacturing and sorting process. Whether the LED grain can be accurately identified and positioned will greatly affect the production speed and efficiency of LED grain. At present, the research on this technology in China is in its infancy. In this paper, a LED grain image recognition and location system based on rectangle detection algorithm is proposed to solve the problem of LED grain image recognition and location. The system uses image grayscale, binarization, edge extraction, contour detection algorithm to process the image of the target image, and uses the matching algorithm and rectangular detection algorithm to identify the LED grain, although the time is short but the accuracy is not enough. Rectangle detection uses two methods to determine contour minima, the getMin() function and the OpenCV library method, using the getMin() function is more appropriate. The LED grain image recognition and positioning system designed in this paper can realize the recognition of LED grain in a simple environment, and can accurately calculate the deflection Angle of LED grain, reducing the time of grain quality detection.

1. Introduction

LED can be said to be very popular. Its luminous principle is different from that of energy-saving lamp and incandescent lamp tungsten wire. It uses electric field to emit light directly. PN junction is a semiconductor particle composed of p-type semiconductor and n-type semiconductor. It is the core part of LED luminescence. Because of its energy saving, environmental protection, size less than 2mm, long service life and other advantages, it is also called green light source. The penetration rate of China's semiconductor lighting market has reached 33%, and the annual output value of LED industry has reached more than 400 billion. It is believed that in the near future, traditional lighting will be replaced by new LED lighting. It can be said that the market prospect of LED industry is very broad.LED grain sorter is an essential production equipment in grain production. Its function is to detect qualified grains, screen these grains and put them on the crystal film. The quality of LED grain sorter determines the quality of LED grains and the benefits of manufacturers. The key to the quality of LED grain sorter is led grain image recognition and positioning system. Taking the quality inspection process of products in the production process of LED grains as the main object, this paper studies the specific application of image recognition and positioning technology in the era of intelligent production of LED grains.
2. **Structure of LED grain sorter**
LED grain separator is composed of a mechanical arm, crystal table, sorting after crystal table, thimble, suction nozzle and two CCD industrial cameras. The structure is shown in Figure 1. CCD1 is used to collect the initial location of grains, and CCD2 is used to observe the sorted grains.[1]

![Figure 1 Structure drawing of LED grain separator](image)

3. **System scheme design**
Firstly, the image recognition and positioning system will directly affect the accuracy and speed of recognition after graying and binarization of the collected image. The contour of the target image after binarization is extracted to obtain the minimum contour that meets the requirements. Then, rectangle detection is carried out, and the recognized led particles are selected with the rectangular box on the target image. After the LED particles are detected, the next step is to locate the LED particles and obtain the angle information. Finally, the processed image and the recognition and positioning result diagram are displayed.[2]

4. **Hardware and software selection**
The camera selects the dmk 23g618 monochrome camera of the imaging source "23" series GigE camera, the lens selects the industrial lens bt-118c2520mp5, and the light source selects the industrial camera LED ring light source. The language used for software programming is python, and the compiler is the Spyder compiler built in anaconda3.

5. **Research on image recognition and location algorithm**
Four steps of image acquisition, image processing, image recognition and image positioning are introduced in detail to the algorithm used in LED grain image recognition and positioning system.

5.1. **Image acquisition**
The Imaging Source DMK 23G618 monochrome industrial camera was selected to collect LED grain samples. Firstly, the corresponding driver and shooting tool software IC Capture should be installed according to the camera manual. DMK 23G618 uses network card transmission, and can achieve the effect of real-time transmission after connecting the camera to the computer. Figure 2 shows the IC Capture operation page. LED grain samples were captured using IC Capture and saved to a computer.[3]
5.2. The image processing
After the image is imported into the computer, the cv2.imread function is used to read the image. Because the image of the sample grain obtained is relatively clear, the steps of noise reduction and filtering are omitted, and only two steps of image grayscale and image binarization are carried out.

5.2.1. Image grayscale processing
In RGB type images, when the R, G and B parameters are the same, the color image will display a gray, and the equal value is called the gray value of the image. Using the function CV2. CvtColor() directly in opencv can complete the processing of image gray.

5.2.2. Image binarization processing
Histogram is an important feature of an image. The principle of histogram method is to find the two highest peaks in the image histogram, and the lowest peak and valley between the two peaks is the optimal solution of the threshold, as shown in Figure 3.

Firstly, otsu algorithm is used to predict the reference threshold, which is 141. Then, based on the reference threshold, repeated experiments and modifications are carried out, and finally the best threshold suitable for this image processing is 70. The image processing results are shown in Figure 4.
5.3. Image recognition

At present, the mature image recognition methods include neural network and wavelet matrix transformation. Neural network needs a lot of training to achieve the purpose of accurate recognition. Wavelet moment has better ability of local feature extraction and is relatively stable.

5.3.1. Matching algorithm

At first, a template matching algorithm in opencv library is used. Just load the target image and the matching template image into the computer respectively, and then set a similarity. The similarity measurement method can choose the average absolute difference algorithm Absolute error sum algorithm, error square sum algorithm, normalized product correlation algorithm and so on. The function match template() is the most primitive and basic identification method. Template is a known small image, and template matching is to search for a target in a large image, and the target has the same size, direction and image elements as the template. Through a certain algorithm, the target can be found in the image and its coordinate position can be determined. Fig. 5 and Fig. 6 are results showing 97% similarity using the matching algorithm.[4]

![Figure 5 Effect display of matching algorithm a](image1)

As can be seen from Fig. 5 and Fig. 6, although the matching algorithm recognizes all 9 LED particles in the target image, many similarities can be found when positioning led particles, and the coordinate distance is very close. The matching algorithm can match more than 9 regions, and the similarity with the template image is 97%. By calculating the time function, the running time of the matching algorithm is about 0.023s. Due to the imprecision of the template, the matching algorithm has large errors in matching and positioning.
5.3.2. Canny edge detection
Because the LED grain is rectangular, the rectangular algorithm is more suitable for this image recognition and positioning system, and the programming is simpler and faster. In different scenes, there is a lot of interference information. If all these features are compared, the amount of calculation will be large. Reducing the number of rectangular features can effectively solve this problem. There are two methods: feature selection and feature extraction. This processing process is called feature extraction, and the changed image features are called secondary features. Many functions about edge detection are provided in opencv, among which Canny edge detection algorithm is widely used. Figure 7 shows the effect of LED grains processed by Canny edge detection algorithm.

![Figure 7 Canny algorithm processing effect](image_url)

5.3.3. Contour detection algorithm
The LED grain is a standard rectangle. After image binarization, the LED grain can be regarded as a rectangle. The lower left corner of the rectangle is a 45° sector and the upper right corner is a solid circle. The function used in contour detection is: CV2. FindContours(). This function can only be used to process binary images. Therefore, it is necessary to ensure that the target image has been binarized. There are four contour detection methods. Cv2.retr is selected here: External, only detect the contour; The contour approximation method selects the contour approximation mode cv2.CHAIN_APPROX_SIMPLE, only 4 points can be reserved.

In contour detection, determining the minimum contour is a very complex thing. This experiment uses a defined function to determine the minimum value of the contour. First, define an array set. The number of elements contained in the array set is the same as len (contours), len (contours) represents the number of detected contours, and the data type of the element is Int64. Then there is a cycle, which assigns values to the c-th element of C and set, and finally obtains the mean value of set and multiplies it by 0.5. Figure 8 shows the effect after processing with the getmin () function.[5]

![Figure 8 Getmin processing effect](image_url)

5.3.4. Image location
About the LED grain positioning algorithm, this topic uses the center point of each LED grain as the positioning point and the upper left corner of the image as the origin to establish a rectangular
coordinate system. Therefore, the first step is to find the center point coordinates of the LED grain. Here, a CV2. Boxpoints() function is used to obtain the coordinates of the four vertices of the rectangle. Here, the representation of four vertices is defined as: take (x1, y1) as an example, x1 as box[1][0], y1 as box[1][1]. Similarly, the four vertices are (box[1][0], box[1][1]), (box[2][0], box[2][1]), (box[3][0], box[3][1]), (box[4][0], box[4][1]). Therefore, the formula is obtained according to the center point of the rectangle:

\[
\text{center} = \left(\frac{x1 + x3}{2}, \frac{y1 + y3}{2}\right)
\]  

(1)

After the coordinates of the center point are obtained, the deflection angle of LED grains can be obtained by using a pre programmed angle calculation function getangle (box). The getangle (box) function is as follows:

```python
def getAngle(box):
x1 = np.array([box[3][0] - box[0][0], box[3][1] - box[0][1]])
x2 = np.array([1, 0])
l1 = np.sqrt(x1.dot(x1))
l2 = np.sqrt(x2.dot(x2))
cos_angle = x1.dot(x2) / (l1 * l2)
angle = np.arccos(cos_angle)
angle2 = angle * 360 / 2 / np.pi
return angle2
```

6. Conclusion
This paper is based on the LED grain image recognition and positioning design system, uses the image recognition and target positioning technology to detect the quality of the produced LED grains, and selects the qualified products, which greatly ensures the quality of the produced LED grains. The principle and related algorithms of LED grain sorting are analyzed, the system design scheme of this subject is proposed, and the design and implementation process of the whole system is introduced in detail.

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