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# A Measurement System for Target Distance and Dimension Based on Monocular Camera

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***ABSTRACT.*** *Target measurement has always been a hot topic in computer vision. Image measurement system can realize accurate measurement without contact. In this paper, a target distance and dimension measurement system based on monocular camera is designed, firstly, the imaging principle of monocular camera and the measuring theory based on similar triangle are introduced. Then, the similarity measurement algorithm based on Gaussian filtering and canny edge detection and implementation steps were analysed and summarized.*

***KEYWORDS:*** *Monocular Camera, Target Determination, Gaussian Filter, Canny*

## 1. Introduction

Computer vision is not only an engineering field, but also a challenging and important research field in the field of science [1]. Computer vision is a comprehensive subject, which has attracted researchers from various disciplines to participate in its research. These include computer science and engineering, signal processing, physics, applied mathematics and statistics, neurophysiology and cognitive science [2-3].

Target measurement has always been a hot topic in computer vision. Image measurement system can realize accurate measurement without contact. At present, linear CCD can be used to measure the size of the target object. There are shortcomings is low accuracy, mainly due to image distance. Most of them are ultrasonic laser ranging, the other is the use of digital processing technology (DSP), the use of C language algorithm programming equipment large volume, programming language cumbersome, low measurement accuracy, poor real-time [4] .this paper, a target distance and dimension measurement system based on monocular camera is designed, firstly, the imaging principle of monocular camera and the measuring theory based on similar triangle are introduced. Then, the

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similarity measurement algorithm based on Gaussian filtering and canny edge detection and implementation steps were analysed and summarized.

## 2. Methodology

### *2.1 Basic content of the Measurement System for Target Distance and Dimension Based on Monocular Camera*

The target measurement system based on monocular camera consists of five processes, figure 1 is the flow chart of the target measurement process.

(1) Select the fixed size reference.

(2) Image acquisition and image recognition (search through color blocks).

(3) Determine whether an image has been collected.

(4) According to formula: K= distance/pixel, caculate the constant K.

(5) Measure the target distance and target size.

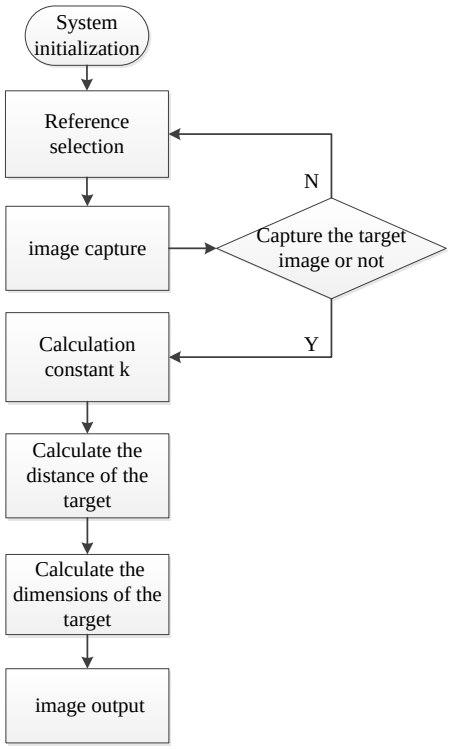


*Figure. 1 Flow chart of the target measurement process*

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### *2.2 Basic technology of the Measurement System for Target Distance and Dimension Based on Monocular Camera*

#### *2.2.1 The Principle of monocular camera imaging*

The physical process of the camera imaging model is to project the space object to the imaging plane. According to the small hole imaging model, the spatial geometric relationship between space object and imaging image can be defined[5]. The projection process of the camera is to project the space object to a sphere (sphere of view) in the world coordinate system, and then to project the image on the sphere to a plane.The schematic diagram of the monocular camera imaging shown in Figure 2.

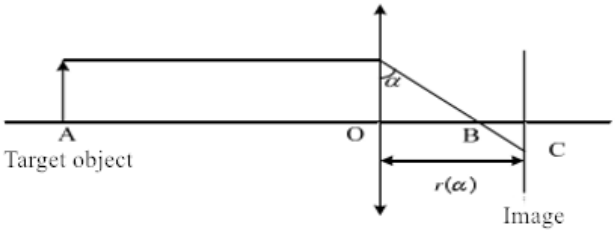


*Figure. 2 The Basic principles of monocular camera imaging*

According to the geometric relation, the imaging mode is:

$$r(\alpha) = k\tan(\alpha) \tag{1}$$

#### *2.2.2 The Principle of Similar Triangle Algorithm*

Suppose there is a fixed size target object, which is placed in a position where the camera is D, the image is collected through the camera, the pixel number of the object is obtained, and then the constant K is calculated.As the figure 3 shown,Assuming that a fixed-size ball is placed 20 centimeters from the camera, the constant K. Can be estimated by the obtained image after the image is collected the distance and dimension of the target image are calculated.

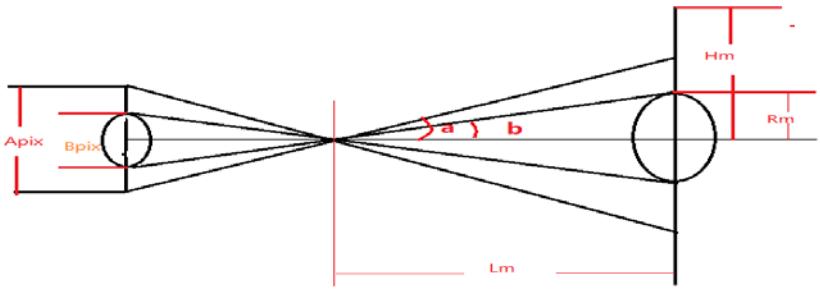


*Figure. 3 The Principle of Similar Triangle Algorithm*

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As the figure 3 shown, the geometry in the left camera:

$$\tan(\alpha) = \frac{Apix}{2L^{'}} \tag{2}$$

$$\tan(b) = \frac{Bpix}{2L^{'}} \tag{3}$$

From equation (2) and equation (3), it can be obtained.

$$\frac{\tan(a)}{\tan(b)} = \frac{Apix}{Bpix} \tag{4}$$

Similarly, the geometric relation of the target object can be obtained in figure 3.

$$\tan(b) = \frac{R_m}{L_m} \tag{5}$$

According to equation (4) and equation (5), it can be obtained.

$$L_m \times Bpix = R_m \times \frac{Apix}{\tan(a)} \tag{6}$$

Where $Bpix$ is the diameter of the ball captured in the image (in pixels), $L_m$ is the distance of the target object, $R_m$ represents the actual radius of the target object, $Apix$ is the model size of a monocular camera, $a$ is the size of the camera view.The distance and size of the object can be expressed as follows.

$$\begin{cases} L_m = \dfrac{K}{Bpix} \\ R_m = K \times \dfrac{Bpix}{2} \end{cases} \tag{7}$$

***2.2.3 The canny Algorithm***

The Canny operator is a multi-stage optimization operator with filtering, enhancement and detection. Before processing, canny operator uses Gaussian smoothing filter to smooth the image to remove noise. Canny segmentation algorithm uses finite difference of first order partial derivative to calculate gradient amplitude and direction. In the process, canny operator will also go through a non-maximum suppression process. Finally, two thresholds are used to connect the edges. The target measurement system based on canny operator can effectively suppress noise and obtain accurate results.

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## 3. Results and discussion

### *3.1 Overall structure design of the Measurement System for Target Distance and Dimension Based on Monocular Camera*

Firstly, the collected information is uploaded to the PC; at the same time, processing software running on PC processes the acquired information and calls the algorithm to obtain the distance and size of the object. The overall structure of the system is designed as shown in Figure 4.

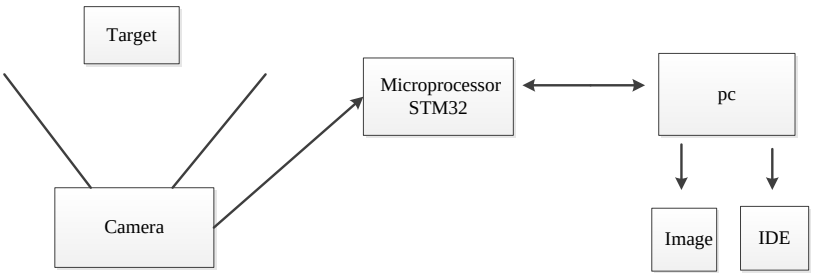


*Figure. 4 System overall structure*

### *3.2 System hardware platform*

The Measurement System for Target Distance and Dimension Based on Monocular Camera needs related hardware and software. In hardware aspect, the system adopts openMV camera. The OpenMV camera is a small, low-power, low-cost circuit board that helps you easily complete machine vision (machine vision) applications. Scripting can be Python in high-level languages rather than C/C++ Python high-level data structure is quickly implemented to process complex outputs in machine vision algorithms The final result of the system hardware platform is shown in Figure 5.

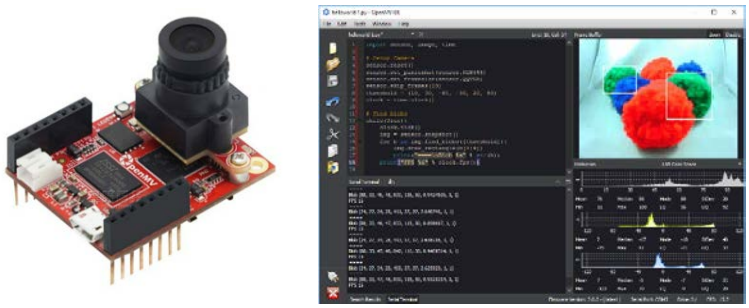

*Figure. 5 System hardware platform*

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### *3.3 Analysis of measurement results*

The experimental results are shown in Table 1 and Table 2. Table 1 is based on the triangulation principle. Table 2 shows the measured data processed by Gaussian filtering and canny edge detection operators.

*Table 1 Experimental data of the general triangulation algorithm*

| Sample | Actual distance | Measuring distance | error(%) |
|---|---|---|---|
| Sample 1 | 85.2 | 60.96 | 0.30 |
| Sample 2 | 82.0 | 78.48 | 0.0414 |
| Sample 3 | 110.1 | 46.54 | 0.5 |

*Table 2 Experimental data of the Improved Triangulation Algorithm*

| Sample | Actual distance | Measuring distance | error(%) |
|---|---|---|---|
| Sample 1 | 85.2 | 84.78 | 0.004 |
| Sample 2 | 82.0 | 81.28 | 0.0087 |
| Sample 3 | 110.1 | 117.15 | 0.06 |

When modeling similar triangles directly, the error of measurement is large and the maximum error is 0.5. After Gaussian filtering and canny detection, the noise interference is removed and the error is effectively reduced. The experimental results show that the monocular camera is easy to be disturbed by noise. In order to improve the application of real-time and rapid measurement, further anti-noise processing is needed.

## 4. Conclusion

As a hot research technology, Real-time target measurement technology has been widely used in various fields. The OpenMV camera based on STM32 is a small, low-power, low-cost machine vision module, using Python language, can achieve real-time, fast ground object recognition and measurement.

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