

Map Drawing Method Based on Visual

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ABSTRACT

In order to achieve map drawing for robots under resource limited conditions, this paper proposes a map drawing method based on image processing technology. By using visual processing techniques, map drawing work can be achieved. After experiments, the effectiveness of this method has been proven, and the error caused in an environment of 100cm * 60cm does not exceed 40mm.

KEYWORDS

Robot map drawing; Image processing

1. INTRODUCTION

Map construction is a crucial step in the entire robot control system, used to obtain information about the robot's motion environment and achieve localization of the robot. The commonly used map creation methods currently include SLAM, visual method, and direct method. Considering that SLAM technology requires a significant amount of resources and requires robots to have strong computing power. In situations where robot resources are limited, cloud SLAM is usually used to create maps. Moreover, SLAM mapping requires robots to run around the site, making the mapping process quite cumbersome. Therefore, the mapping process used in this article is completed visually.

On the basis of visual processing technology, this article uses a visual based drawing method. This method mainly uses camera calibration and perspective transformation to complete[1]. Implemented mapping work under resource constraints and demonstrated the accuracy of this method through experiments.

2. SYSTEM DESIGN

2.1. System Overview

The robot system targeted in this article's mapping work is carried out in an indoor environment. A vertical camera is fixed above the experimental site to achieve real-time acquisition of site images and robot motion images. When drawing, the site image is captured by the camera, and then transmitted to the upper computer module through wireless communication. Finally, the image is processed on the upper computer and the processing results are saved. From now on, all images collected must be processed according to the processing results, as shown in Figure 1 of the system diagram.

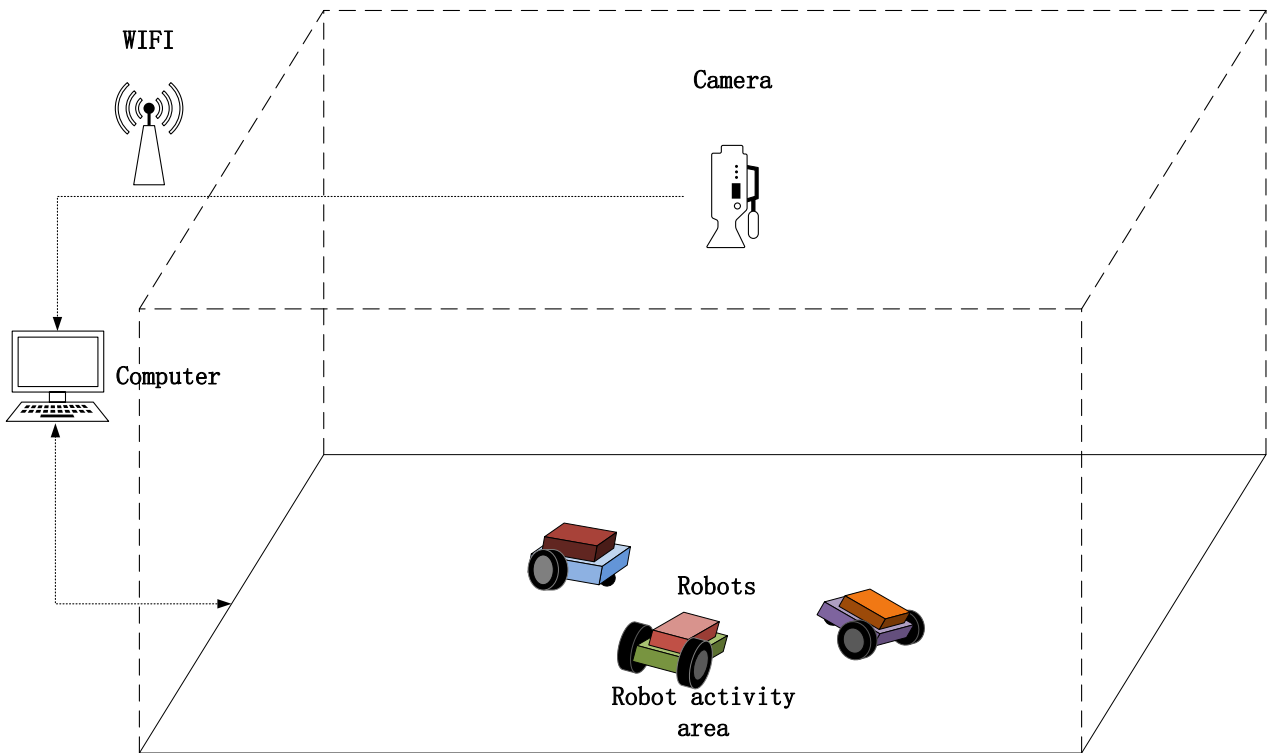


Figure 1. System diagram

Camera module: The information acquisition module is responsible for collecting robot information. It can perform simple image processing according to needs, and then send the processed data to the upper computer module for further processing of the image on the upper computer.

Computer module: This module is mainly responsible for processing data, completing the tasks of drawing maps and planning robot motion paths, and sending control instructions to each robot to achieve motion control of each robot.

2.2. System Hardware Design

The mapping method used in this article mainly involves two parts of equipment, namely the upper computer and the camera. The upper computer uses a regular personal computer, and the camera is composed of a CPU and photosensitive devices. Its model is shown in Table 1.

Table 1. Camera hardware composition

name	model
CPU	ESP32-S3-WROOM-1
Photosensitive device	OV2640

CPU: The processor model is ESP32-S3-WROOM-1. This processor is equipped with Xtensa® A 32-bit LX7 dual core processor with a working frequency of up to 240 MHz, featuring a 384KB ROM and 512KB SRAM. This processor comes with a built-in WiFi module, with a data rate of up to 150 Mbps in 802.11n mode. This processor also comes with a variety of peripherals, including GPIO, SPI, Camera interface, UART, I2C, PWM, timers, and watchdog, among other commonly used peripherals.

Sensor: The sensor model is OV2640, which is a high-performance, low-power CMOS image sensor with a resolution of over 2 million pixels. Pixel size is $2.2 \mu\text{M} \times 2.2 \mu\text{m}$. The image transmission rate can reach 60fps and accept output formats such as YUV, RGB, JPEG, etc.

2.3. System software composition

The main tasks of image acquisition device software are image acquisition tasks and data transmission tasks. This software is mainly responsible for collecting images and sending them to the upper computer[2].

Image acquisition task: This task is mainly responsible for image acquisition, which is mainly completed by calling the library provided by the manufacturer. Due to the porting of OpenCV on the camera, some simple image processing algorithms can be performed on the camera.

Data transmission task: This task is mainly responsible for sending the images captured by the camera to the upper computer. The transmitted data is mainly the images captured by the camera and transmitted through TCP/IP protocol

3. MAP DRAWING

The image processing techniques involved in map drawing in this article mainly include camera calibration, color recognition, and perspective transformation.

In image measurement and machine vision applications, camera parameter calibration is a crucial step[3]. Because these parameters determine the spatial relationship between a point on the surface of a spatial object and its corresponding point in the image. These parameters are determined through necessary calculations, a process known as camera calibration or camera calibration. Through camera calibration, the internal and external parameters of the camera can be calculated, further achieving distortion correction of the image.

Projection transformation is the process of transforming objects or objects in three-dimensional space into two-dimensional image representations, which is a common technique in computer graphics and visual computing. According to the relative distance between the projection center and the projection plane, projection can be divided into two forms: parallel projection and perspective projection[4]. Perspective transformation is commonly used in the research of mobile robot visual navigation. Due to installation reasons, the camera lens cannot be completely parallel to the ground, and there will always be a certain tilt angle between the lens and the ground, which cannot obtain a vertical image. Sometimes it is necessary to use perspective transformation to correct the image into a vertical image form. The essence of perspective transformation is to project an image onto a new plane[5].

The flowchart for drawing the map in this article is shown in Figure 2.

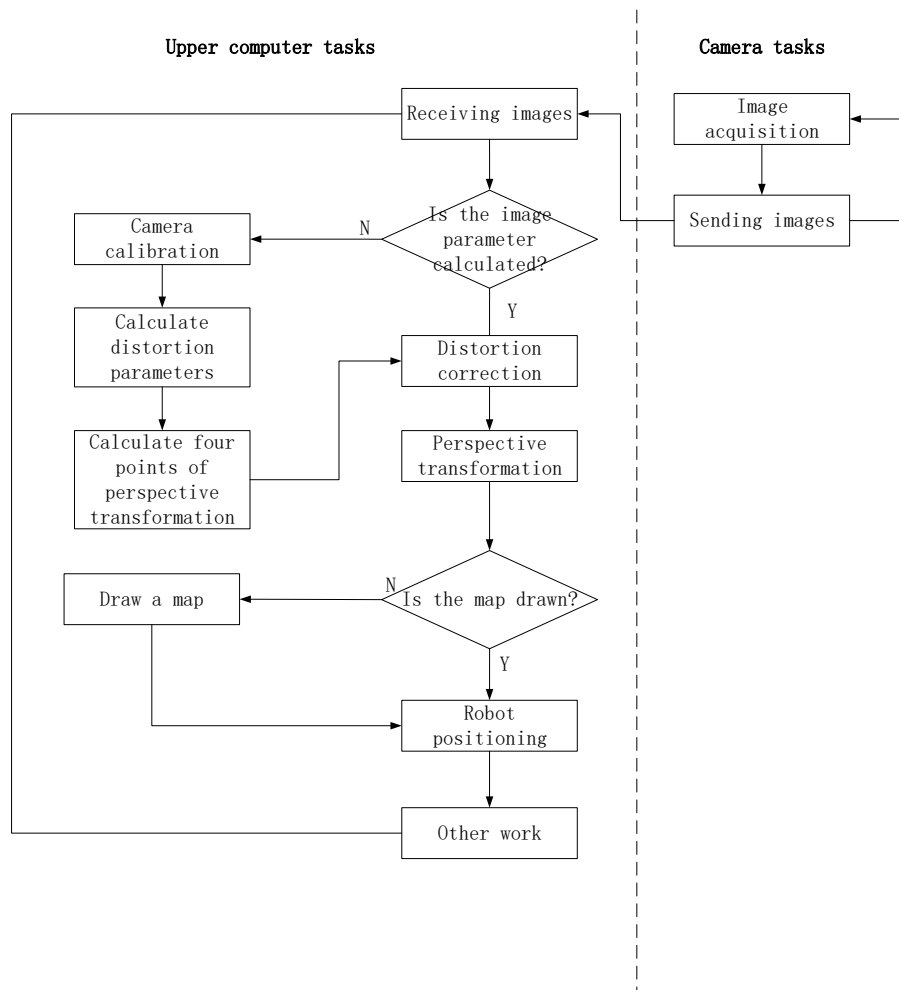


Figure 2. Task flowchart

4. EXPERIMENT

The experimental site for this experiment is a robot small table, which has a size of 100cm * 60cm and a height of 55cm, as shown in Figure 2 (a). Set up the camera above the venue, about 170cm above the ground, and shoot the venue vertically. Then, the image is subjected to perspective transformation to obtain an almost vertically captured image, which is used as a map for experiments. Place a marker in the experimental site, identify it on the computer, record the coordinates of the center point of the marker, and then calculate its distance from the origin (position in the top left corner of the map in the image). Then use a tape measure to measure the true distance between the center point of the marker and the origin of the map. The measurement results are shown in Table 2.



(a)



(b)

Figure 3 Experimental Site and Map

Table 2 Positioning experiment results

Times	Identifying coordinates (x, y)	Distance from origin (mm) (x, y)	Measure distance (mm) (x, y)	error(mm) (x, y)
1	46, 46	92,, 92	130, 125	38, 33
2	419, 33	838, 66	860, 83	22, 17
3	307, 160	614, 20	637, 307	23, 13
4	271, 248	542, 596	554, 557	16, 39
5	317, 116	634, 232	653, 238	19, 6
6	184, 152	368, 304	397, 305	29, 3
7	96, 109	192, 218	225, 253	33, 35
8	218, 270	436, 540	451, 511	15, 29
9	381, 157	762, 314	770, 331	8, 17
10	231, 31	462, 62	491, 90	29, 32

From the experimental results, it can be seen that this method has certain errors, which are related to the four points that need to be calculated in the perspective transformation. The error can be reduced by manually importing the coordinates of four points.

5. CONCLUSION

This article provides a detailed description of the working principle and implementation process of a robot drawing method based on visual technology. The experiment proves that this method can complete the mapping work.

However, in this design, there may be errors due to the fact that the calculation of the four points of perspective transformation is completed by the program. If you want to reduce the error, you can manually import the coordinates of four points. Therefore, in future experiments, the focus of work will be on the accuracy of coordinate calculations to achieve more accurate map effects.

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