A New Information Code for Robot Localization

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Abstract. Localization is the basic problem of mobile robot. A new approach for information coding and decoding for robot localization is proposed in this paper. Information codes are used as landmarks to provide a global attitude reference. The label and location information is stored in the information code and strategically placed in the operating environment. The mobile robot is equipped with a camera that can read the information code for localization purposes. Firstly, the current situation of the coding methods used for robot localization is analyzed, and the exposed problems and defects in application are summarized. In view of these problems, a new code method which is more suitable for robot location is designed. Then, the coding and decoding methods of the design are elaborated in detail. Finally, relevant experiments are designed in combination with practical application scenarios. Compared with the traditional QR code decoding method, the effect is better than the traditional QR code.

1. Introduction

Bar code information identification technology is a group of bar and empty symbols arranged according to certain coding rules to represent certain characters, numbers and symbols of information technology. In today's automatic identification technology plays an important role[1].

With the development of computer technology, in view of the shortage of one-dimensional code storage capacity, as shown in the figure 1, the generation of two-dimensional code, and widely used in life. The two-dimensional code uses a certain geometric graph to record data symbol information in the black-and-white graph distributed in the two-dimensional space according to a certain law. The most common type of two-dimensional code is the QR code[2], as shown in the figure 2. Automatic information processing can be realized by automatic image input device or photoelectric scanning device[3], as shown in the figure 3.

![Figure 1. One-dimensional code](image1)

![Figure 2. QR code](image2)

At present, robot localization can be divided into two major localization methods, one of which is SLAM (simultaneous localization and mapping) localization based on a variety of sensors of the robot itself. The other is to help the robot locate by modifying the environment around the robot, such as setting the QR code and setting the location of the communication base station[4]. The QR code as a
means of robot aided positioning, also have a variety of implementations[5]. There is a kind of method in the center of the bottom of the mobile robot location to install a vision industrial camera perpendicular to the ground. At the same time in the indoor ground according to certain interval laying a certain number of QR code[6]. The QR code reader on the robot will shoot the QR code every time it passes through a QR code, and then take the included Angle formed by a set of opposite edges of the QR code at the center of the robot and the straight line along the direction of the robot and the linear distance between the two lines of the included Angle as the criterion for judging the Angle deviation of the robot[7]. There is also a method to use QR codes as landmarks to provide a global attitude reference. The label and location information are stored in the QR code. The mobile robot is equipped with a camera pointing to the ceiling to detect the QR code, and the robot's posture can be estimated according to the relationship between the two-dimensional code and the robot's position[8]. In addition, it is applied to the wall of the power distribution room to establish a spatial database in the range of positioning services needed, similar to the map used for GPS positioning. In the power distribution room, it is necessary to locate every equipment in the power station, including the geographical location, equipment attributes and data types to be detected in the space where each detected device is located. The geographical location of the device is equivalent to a coordinate in the spatial database. When the robot moves here, it can scan the QR code to obtain all the information of the device. According to the spatial location of the device, the location of the robot can be calculated and displayed on the display screen and the console[9]. In addition to indoor mobile robots, industrial robot loading and unloading systems, unmanned aerial vehicle systems and other mobile robot systems are all using QR codes for visually assisted positioning. As an important supplementary means of VSLAM (vision simultaneous localization and mapping), its application scope is still expanding.

In machine vision projects, the development of QR code location and recognition will face the following challenges: (1) In order to decode the universality of the module needs to adapt to different industrial environments. (2) In a moving scene, a static picture-taking is required. (3) Information loss caused by code area distortion, deformation, blurring, etc. (4) Industrial sites often need more stable and real-time decoding of the two-dimensional code.

![Figure 3. Robot location based on QR code](image)

### 2. New encoding and decoding theory

Different from the Internet and other fields, the robot positioning field of coding has its own needs. Since only the serial number representing the corresponding location needs to be obtained from the code in robot positioning, and 256 serial Numbers can be stored in one byte, it is not necessary to store a large amount of information like QR code. In addition, in the application scenario of robot positioning, if it can have the characteristics of motion recognition, it can improve the flexibility of the robot itself. The efficiency of image recognition is greatly reduced when motion blur is encountered in traditional QR code recognition, so it is expected that the coding used for robot positioning can have better recognition accuracy and recognition characteristics in motion. The main characteristics of the existing two-dimensional code is the large amount of information stored, error correction ability. However, there are still shortcomings in recognition rate and effect[10]. Therefore, on this basis, this paper proposes a new encoding and decoding method for localization, which greatly simplifies the
decoding process by changing the encoding method and redesigning the encoding structure. At the same time, the code area becomes a circle, which can be better identified in the case of motion or image blur, improving the recognition effect, as shown in the figure 4.

![Figure 4. New information code](image1)

Machine when decoding, as shown in the figure 5, the round of 16 slices, calibration each equal radius and hexadecimal symbols, starting from the center of the circle of detected, with the increase radius, threshold and set according to the line width, arc track width greater than the threshold can let the machine visual inspection to the circle there are five width and interval are equal arc trajectory. a, b, c, d, e, which arc trajectory do not allow the closure:

- a: The starting point of the trajectory arc is 0 and the ending point of the arc is 5, so byte 05 is generated.
- b: The starting point of the trajectory arc is 3, and the ending point of the arc is A, so byte 3A is generated.
- c: The starting point of the trajectory arc is 4, and the ending point of the arc is 1, so byte 41 is generated.
- d: The starting point of the trajectory arc is B, and the ending point of the arc is 6, so byte B6 is generated.
- e: The trajectory has no starting point and ending point of the arc, but passes through the corresponding equipartition radius of 4, so byte 44 is generated.

When the machine detects the edge of the closed circle, the generated string 0H is used as the terminator and the detection generation process ends.

Therefore, five byte encodings are obtained from the five arc trajectories, which are combined together with the terminator in turn to form a byte string:053A41B6440H, and the part before 0H is taken as a valid byte string encoding.

![Figure 5. Schematic diagram of encoding and decoding](image2)

3. Experimental comparison

In order to ensure the consistency of the experiment, the QR code image and the image encoded in this paper are processed in the same way. The actual fuzzy situation is simulated and the recognition effect of the two codes is compared. Among them, QR code recognition adopts the QR code recognition module in Halcon software. The following flowchart is used to identify the code in this paper, as shown in the figure 6.
3.1. contrast with QR code recognition effect under the same out-of-focus degree.
Out-of-focus blurring is an image degradation phenomenon caused by out-of-focus of the target object and the imaging target in the imaging equipment. Lenses have a limited depth of field, only objects at the right distance are clear, and the rest of the physics is blurred in proportion to their distance. It can be seen from the defocus geometric light path that a defocus point light source will present a uniform grayscale disk on the image.

A circular region mean filter with a radius of 5 is used to simulate camera defocus, as shown in the figure 7 and figure 8.

![Figure 7. Same out-of-focus blur](image)

![Figure 8. Sobel edge detection](image)

It can be seen from the above figure that in the case of defocusing blur, only the width of the ring is affected, but the starting and ending positions of the ring are not changed, which will not affect the recognition effect. But for the QR code, has been completely unrecognizable.

3.2. contrast with QR code recognition effect under the same motion blur.
Motion blur is a kind of image degradation phenomenon caused by the relative displacement between the camera and the photographed target during the exposure time.

In general, the relative motion degradation model can be simplified to the linear uniform motion degradation model, as follows:

\[ h(x, y) = \begin{cases} \frac{1}{d} \sqrt{x^2 + y^2} & \frac{d}{2} \cdot \frac{x}{y} = -\tan\theta \\ 0 & \text{elsewhere} \end{cases} \]

h is the degenerate function, \( \theta \) is the motion fuzzy Angle, and d is the motion fuzzy displacement. The motion displacement is set to 20 pixels and the motion Angle is set to 15 degrees to process the image and simulate the blur caused by motion, as shown in the figure 9, figure 10 and figure 11.

![Figure 9. Motion fuzzy displacement is 5 (A), 10 (B) and 15 (C), fuzzy Angle is 15](image)
Figure 10. Motion fuzzy displacement is 20 (D), 25 (E) and 30 (F), fuzzy Angle is 15

Figure 10. Figure 10. (E) and (F)’s sobel edge detection

TABLE 1. COMPARISON OF IDENTIFICATION RESULTS

| Motion fuzzy displacement | QR code identification results | This paper code identification results |
|---------------------------|---------------------------------|----------------------------------------|
| 5                         | Yes                             | Yes                                    |
| 10                        | No                              | Yes                                    |
| 15                        | No                              | Yes                                    |
| 20                        | No                              | Yes                                    |
| 25                        | No                              | Yes                                    |
| 30                        | No                              | No                                     |
| Out-of-focus blur         | No                              | Yes                                    |

By analyzing the comparison results of the above figure, as shown in table 1, when the pixel displacement of motion blur reaches 10, the QR code cannot be identified. As can be seen from the corresponding effect figure, the displacement of 10 pixels is only slight jitter. However, the coding in this paper fails to recognize when the pixel displacement of motion blur reaches 30.

4. Conclusion

In this paper, a new approach of encoding and decoding for robot localization is proposed. The proposed encoding and decoding method is described in detail, and finally designs relevant experiments in combination with practical application scenarios. Compared with the traditional two-dimensional code decoding method, the result is better than the traditional two-dimensional code, which provides a new method and idea for solving the problem of robot positioning and improving the accuracy and robustness of robot localization.

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