Development of Guide Robot by Using QR Code Recognition

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Abstract

In this paper we describe the development of guide robot by using QR code (Quick Response Code) recognition. We propose to use a QR code as a landmark of a guide route and implement the navigation system that can perform the autonomous run throughout the guide route by using real-time QR code recognition. By the experiment, it is shown that an autonomous guiding function was achieved. The average deviation gap from the ideal guide route was 6.29 cm. As a result, the effectiveness of the proposed system is confirmed.

***Keywords**:* Guide robot, QR code, Navigating system, Autonomous guiding

1. Introduction

This research receives a request from The Okiden Global Systems Company and Okinawa Electric Power Co., Inc. which aims to develop the robot (henceforth, guide robot) that autonomously guides a company's visitor to a purpose place in the company, e.g. a conference room, a reception room and so forth.

The guide robot runs, leading a visitor from a starting place to the purpose place, then returns back to the starting place again. Therefore, the guide robot is requested to grasp a guide route and run correctly throughout the route.

In this research, we propose to use a QR code as a landmark which indicates a guide route and implement the navigation system that can perform the autonomous run throughout the guide route by using real-time QR code recognition.

This paper describes the outline of the navigation system, and an evaluation experiment.

2. Navigation System Using QR code

Since, the QR code (Quick Response Code) has many advantages. Such as, (1) it is easy to produce; (2) it can store a large number of data; (3) it is provided with the error correction function, which is strong to dirt or breakage; (4) high-speed reading is possible for QR code from every direction[1],[2],[7]. However, there is a problem that a recognition rate will fall remarkably when the distance of QR code and a camera becomes far.

This research proposes to stick QR code used as a landmark on the ceiling for a guide route, so that the distance of QR code and a camera is fixable, the problem that a recognition rate falls by distance is solvable.

The proposed navigation system using QR code recognition is mounted on a three-wheel moving robot for the purpose of guiding the company's visitor.

Since QR code serves as a passive landmark, to print on paper once, it can lessen the burden of a maintenance very much compared with the things using the device which need the battery such a conventional infrared rays and ultrasonic wave sensor[3],[4]. Furthermore, QR code is not necessary to embed to a wall or a floor, installation of a landmark is easy, a change of a guide route can be made easily, and there is a benefit that cost can be held down.

3. Development of guide robot using QR code

3.1. System configuration and development environment

Moving robot used for this research is the Pioneer-3 of ActivMedia[5], which shown in Fig.1. This moving robot is connected to notebook PC via serial connection RS-232C.

A notebook PC is used for a video image processing of QR code recognition and a robotic control. Video images are captured to PC by using USB camera. The specification of notebook PC and USB camera is shown in Table 1 and Table 2.

This research used software named Aria of MobileRobots[5] for robotic control and used the library included in HALCON 9.0 of MVtec Software[6] for QR code recognition. QR codes used for a landmark are printed on A4 paper.

Fig. 1 System configurations

Table. 1 Specification of the notebook PC

OS	Windows XP Professional
CPU	Intel Core(TM2) Quad CPU Q6600 2.40 [GHz]
Memory	2 [GB]

Table. 2 Specification of the camera

Camera model	Microsft LifeCam HD-5000
Resolution[pixel]	1280×720(max),640×480(use in this research)
Frame rate [fps]	30(max),15(use in this research)

3.2 Outline of the system

As shown in Fig 2, QR code used as a landmark is stuck on the ceiling for a guide route at about 1.2 [m] interval. The upper part of QR code is turned to the running-direction.

Fig. 2 QR codes stuck on the ceiling

Proposed system recognizes QR code to acquire (1) the angle, (2) the XY coordinates and (3) the data of QR code as shown in Fig 3.

Based on these pieces of information, guide robot can grasp surround situation and execute autonomous run, to lead the company's visitor from the starting place of navigation, to the purpose place, and then automatically return to its starting place again.

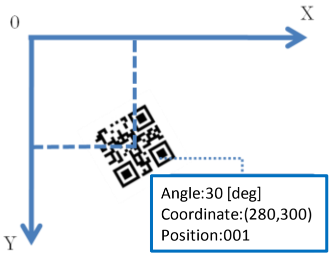

Fig. 3 Each information obtained from QR code recognition

3.3 Grasping the position of a guide route

Figure 4 shows the easy example of the guide route from "START" to "ROOM1". The data stored in QR code is made such as "START","001","L01","002","003","R01","004","ROOM1". The "Lxx" means to turn left and "Rxx" means to turn right. Navigation system then can control the moving robot and grasp its position by these pieces of information to run autonomously.

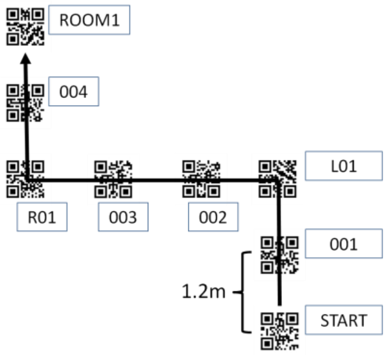

Fig. 4 Example of guide route by QR code

3.4 Detecting angle of QR code

Since the upper part of QR code is turned to a running-direction, then we set the angle of QR code that turned in this direction into 0[deg] as shown in Fig.5. The system keeps the angle of QR code nearly to 0[deg] while running. If the angle of QR code is zero, it means that the robot is running in correct direction. Otherwise, system will adjust the direction with negative or positive value to correct the running-direction.

After the robot arrives at the purpose place, the route along which it passed up till now must be traced inversely, in order to return back to starting place again.

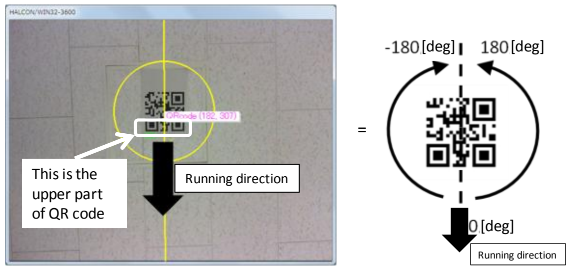

Fig. 5 The angle of QR code and running-direction

3.5 Adjusting of the running-direction

The robot must run truly under QR code used as a landmark as much as possible. We consider the vector for correcting a running direction using the angle of QR code and the XY coordinate value on a screen as shown in Fig.6 In this figure, P is the center of image obtained from the camera. It indicates a guide-robot's coordinate. H is the crossing point of the perpendicular taken down to the direction line. PH is the vector from P to H. HH' is the vector that indicates running-direction. D is the vector that will be used to control a running-direction of guide robot. Vector D is computed by a formula (1) and (2). The angle that should turn is computed by a formula (3).

The more guide robot has deviated gap greatly from real route, the more length of PH is long. Then running-direction will be adjusted quickly by the value of vector D to approach a guide route more. The more angle of vector D calculated by the formula (3) is close to 0 [deg], the more guide robot runs in the right direction. The image of corrected running-direction which computed by these formulas is shown in Fig 7.

$$\vec{D} = r\frac{\overrightarrow{PH}}{\left|\overrightarrow{PH}\right|} + (1-r)\frac{\overrightarrow{HH'}}{\left|\overrightarrow{HH'}\right|} \quad \text{..........(1)}$$

$$r = \frac{\left|\overrightarrow{PH}\right|}{240} \quad \text{..........(2)}$$

$$\theta = \tan^{-1}\left(\frac{D_y}{D_x}\right) \quad \text{..........(3)}$$

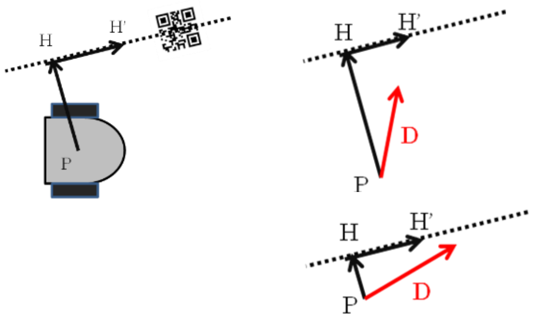

Fig. 6 Calculating of the running-direction.

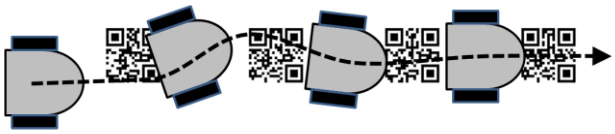
Fig.7 Correcting of the running-direction

4. Experiment and Results

4.1 Measurement the range of camera view that can recognize QR code.

The preliminary experiment is conducted to measure the camera's range of view, and investigate whether it is impossible to recognize QR code or not. As shown in Fig.8, the height of ceiling is 270 [cm]. The height position of camera attached on the moving robot is 80 [cm]. The distance between camera and ceiling is therefore 190 [cm]. As a result, we can confirmed that camera's range of view is 155X115[cm], and QR code in this range can be recognized. From this range of view, we knew that one pixel of the image is 0.272 [cm] in the real world. It means that the deviation gap from ideal guide route should be within ± 77.5 [cm].

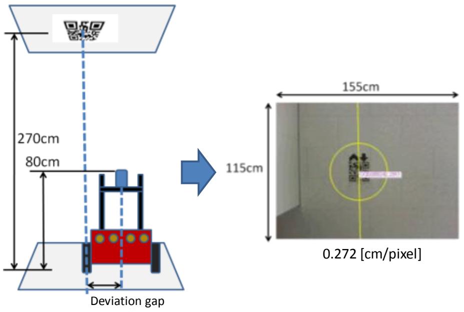

Fig. 8 Deviation gap of running position and range of camera view that can recognize QR code.

4.2 Running experiment with the guide route

4.2.1 Experimental guide route

We created the guide route for the running experiment. 24 QR codes are stuck on the ceiling of corridor at about 1.2 [m] interval. However, only the starting place, turning point and the purpose place are illustrated as shown in the Fig.9. This experiment aims to confirm whether or not the robot can perform autonomous run from starting place to purpose place and return to starting place again.

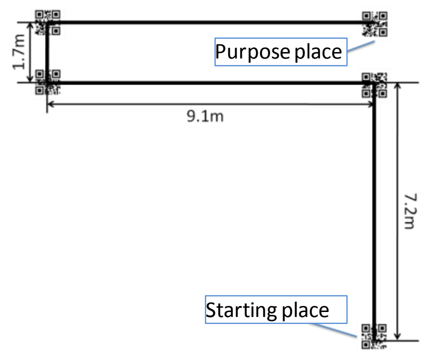

Fig. 9 A guide route made for experiment.

Deviation gap is measured during the run every single frame of a camera. This value is calculated by formula (4).

$$\text{Deviation gap} = (X_Q - X_C) \times 0.272 \text{ [cm]} \quad ....(4)$$

Where, X_Q is X coordinate of QR code.
X_C is X coordinate of center of image

The more X coordinate value of QR code is close to 320 (X coordinates of a center of image), the more a guide robot runs just under QR code.

4.2.2 Measurement result of running position

The experimental result is shown in Fig.10. The ideal guide route is shown by the dotted line. It turns out that the running position is swelling and running outside for a while near a turning point. However, trajectory is corrected immediately and robot can run correctly without deviating after that.

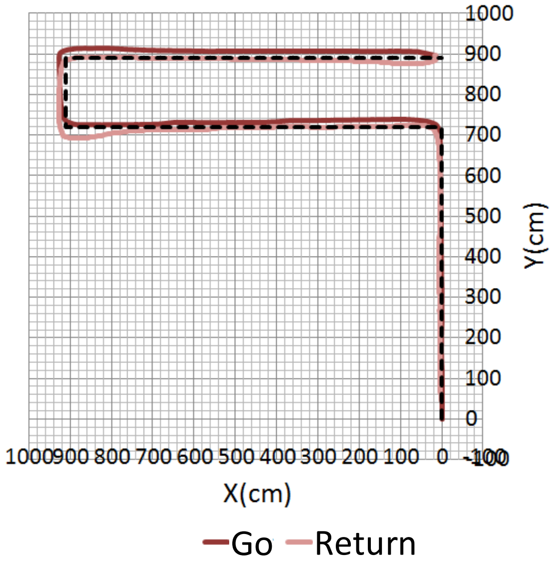

Fig. 10 Measurement results of running position.

4.2.3 Measurement result of deviation gap

The measurement result of deviation gap is shown in Fig.11. Horizontal axis is a frame number of video images. Vertical axis is deviation gap [cm].

The experiment result showed that average of deviation gap was 6.27 [cm]. Some spots of deviation gap are suddenly large because of robot run outside of route for a while near the turning point. However, the maximum value of horizontal deviation gap is 32.9 [cm]. There is no deviation gap larger than ± 77.5 [cm]. There is no run outside the range that cannot recognize QR code. It can be said that autonomous run by using QR code recognition was achieved.

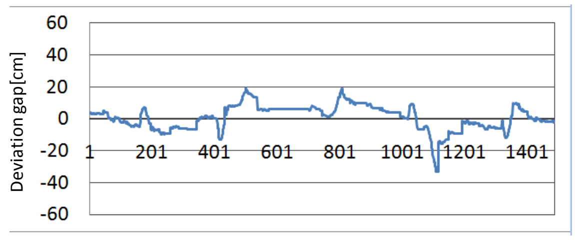

Fig.11 Measurement results of deviation gap.

4.2.4 Measurement result of angle of QR code

The measurement result of angle of QR code during run is shown in Fig.12. Horizontal axis is a frame number of video images. Vertical axis is a detected angle of QR code.

From this result, each QR code arranged as a guide route is recognized correctly, i.e., ± 90 [deg] the turning point, 180 [deg] at the purpose place and converges to 0 [deg] at straight-portion.

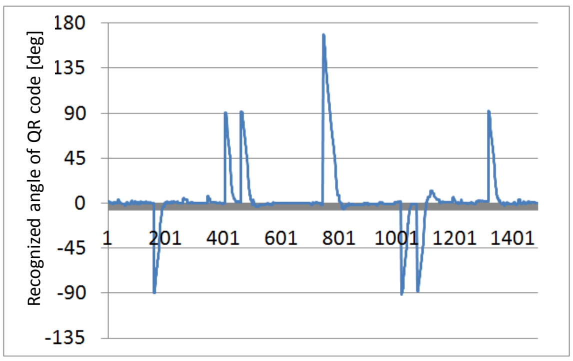

Fig. 12 Recognition angle of QR code.

5. Consideration

By the experimental result, it is shown that the proposed system was able to achieve the run throughout a guide route. An average of deviation gap throughout the route is 6.29 [cm] and the maximum value is 32.9 [cm]. This value is in the view of camera that QR code can be recognized. Therefore, it is proved that the proposal technique in this research is effective.

The frame rate of images processing was 10.39 [fps]. The real-time processing in this system is preserved in general.

6. Conclusion

In this paper, an autonomous guidance robot using QR code recognition was proposed. The experiment environment which has arranged QR code in the corridor was created. The experiment which makes a guide robot perform the autonomous run throughout the route was conducted. The average deviation gap from the ideal guide route was 6.29 [cm]. The validity of the proposal technique was shown.

However, since there is a running outside at the turning point, it needs to improve the algorithm to correct the running-direction so that accuracy may improve in the further.

7. Acknowledgement

Development of the system in this research was carried out based on the guide robot's specification of Okinawa Global Systems Company and Okinawa Electric Power Co.,Inc. We appreciate deeply to Okinawa Global Systems and Okinawa Electric Power Co., Inc. which you had given the opportunity of development.

8. References

[1] HARA Masahiro(2008). Development of QR Code,*Journal of Society of Automotive Engineers of Japan,* 62(1), pp.59-64.

[2] QR code features; DENSO WAVE INCORPORATED,http://www.denso-wave.com/QR code/qrfeature-e.html, access on 10/07/2011

[3] Soo-Yeong YI(2003), Global Ultrasonic System for Self-Localization of Mobile Robot, *IEICE TRANSACTIONS on Communications,* Vol.E86-B No.7 pp.2171-2177.

[4] Toshio ITO Tetsuya SATO Kan TULATHIMUTTE Masanori SUGIMOTO Hiromichi HASHIZUME(2009), A Scalable Tracking System Using Ultrasonic Communication, *IEICE TRANSACTIONS on Fundamentals of Electronics, Communications and Computer Sciences,* Vol.E92-A No.6 pp.1408-1416.

[5]MobileRobots' Advanced Robot Interface for Applications (ARIA), MobileRobots Inc., http://robots.mobilerobots.com/wiki/Aria, access on 10/07/2011

[6]HALCON developer's Kit, LinX Corporatio,http://www.linx.jp/product/halcon_kit/index.html, access on 22/06/2011

[7] Eimon, Koki; Anezaki, Takashi; Tansuriyavong, Suriyon, Yagi, Yasushi(2011): "Development of Human-Tracking Robot by Using QR code Recognition", IEEJ Transactions on Industry Applications, Volume 131, Issue 2, pp. 151-158.