BAR CODE DETECTION USING OMNIDIRECTIONAL VISION FOR AUTOMATED GUIDED VEHICLE NAVIGATION

Z.Taha[a], J. A. Mat-Jizat[b], I. Ishak[c]

Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600, Pekan, Pahang, Malaysia

[a]zaharitaha@ump.edu.my, [b]arifjizat@gmail.com, [c]ismayuzri.i@gmail.com

Keywords: AGV, omnidirectional vision, barcode, landmark,

Abstract

In this paper, a study on detectability and readability of barcodes using omnidirectional vision system for automated guided vehicle is presented. Images from omnidirectional camera are known to be distorted against the height of the object. We present an algorithm for detecting and reading barcodes successfully without correcting the image distortion. Experiments were conducted both when the AGV was in motion and at rest. Three contributing factors were identified for successful barcodes detection and reading.

1 Introduction

Automated guided vehicle (AGV) is very useful mainly for material distribution in flexible manufacturing environment. It can be categorized into fixed-path and free-ranging AGV. Fixed-path AGVs utilize physical guidepath such as wires, rails, magnet or lines while free-ranging AGVs navigate around their environment without depending on physical guide path. AGV is considered as mobile robot on fundamental level.

The developments of reliable vision sensors have spearheaded the development of free ranging AGV. Vision sensors enable larger amount of information to be processed simultaneously compared to ultrasonic or laser-based system. Guidepaths, landmarks, or obstacles identification can be made with a single vision system whether it is monocular, binocular (stereo), trinocular or omnidirectional vision system.

Omnidirectional vision system offers a 360° field of view. The wide field of view enables the AGV to learn its environment in the shortest time without the need of camera panning or tilting [6]. Another significant advantage is that the object of interest will remain in the field of view of the camera once detected even if the AGV makes hard or sharp turns in case of obstacle avoidance. This makes omnidirectional vision system among the best range sensor for landmark-based navigation.

C.J. Wu and W.H Tsai proposed the use of omnidirectional camera for indoor navigation [7]. Their work shows that the distorted images obtained from the omnidirectional camera can be used for landmark recognition without the need for the distortion to be corrected. They used circular landmarks that appear elliptical in some parts of the images obtained and developed an algorithm to detect both circles and ellipses as landmarks.

Landmark-based navigation for mobile robot using vision sensor has been extensively research especially in indoor environment. In indoor environment such as office corridor or manufacturing floor, artificial landmarks can be placed in a specific position in order to help AGVs navigation and localization. Among objects that have been used as landmarks are fluorescent lamps [3], circular objects [7], RFID tags, [5] and barcodes [2,4,1].

Gouyu Lin and Xu Chen [4] proposed a method for robot indoor position and orientation based on 2D barcodes. Information on the x- and y-axes as well as heading for the robot was embedded into their custom design 2d barcode. They also suggested that the landmarks to be placed on the ceiling to minimize landmark occlusion in the camera field of view. Their simulated experiment shows repeatability, operational convenience and robust systems. However, it is very difficult to mount landmarks on the ceiling in this study. The ceiling in the environment for the AGV in this study has a height of about 20m .

J.W. Huh et al. [2] presented another interesting approach by using invisible barcodes with topological information. The barcode was printed using invisible ink on the floor 3.75cm apart. As the position of each of the barcodes is known, the navigation can be computed by connecting the barcode indices from start position to the destination. It shows that the information from the barcode can be use for navigational points because exact position of the barcode is known in prior.

The approach taken in this paper is similar to the paper presented by A.J Briggs et al [1]. The approach makes use of barcodes as artificial landmarks attached to the object of interest. However, instead of using custom design barcode, we employed standard 1D barcode and an omnidirectional vision system.

The standard barcode is widely used as machines tag for asset inventory. By using the same enlarged tag, the AGV can localize itself about the machine as the tag is usually encoded with a unique number. Therefore, the AGV can still perform the same task on the machine station even if the machine were moved due to layout changes.

In this paper, the detectability and readability of barcodes using omnidirectional vision system are examined. The paper is organized as follows: section 2 details the barcodes detection procedure, section 3 gives the experimental setup and results, and section 4 gives the conclusion.

2 Barcode detection

Omnidirectional vision system offers a 360° field of view.The image however is distorted against the height of the object as presented by Z. Taha et al [6]. However, as shown in figure 1, although the height of the object is distorted, the width ratio is still intact. This enables the barcode to be detected even though the barcode image is distorted. It means no distortion correction is necessary prior to the barcode detection.

Figure 1: Barcode detection on distorted image.

The proposed algorithm, as depicted in Figure 2, consists of three main components. The first component is the preprocessing of the images. Images from omnidirectional camera are filtered in order to take advantage of the maximum contrast of the printed barcodes. The images were converted into grayscale format and go through histogram leveling to find the clearest image of the barcodes.

The second component is locating and decoding the barcode. The barcode need to be detected first by the edge, before it can be decoded. Since the AGV is using omnidirectional camera, the barcode needs to be readable from all direction. This can be achieved by scanning the barcode through multi angle lines. The edge widths are then calculated in order to decode the barcode

The last component is AGV navigation. The code from the barcode is then used to plan the navigation of the AGV. The instructions can be embedded into the barcodes so that the AGV know what to do next after decoding the barcodes.

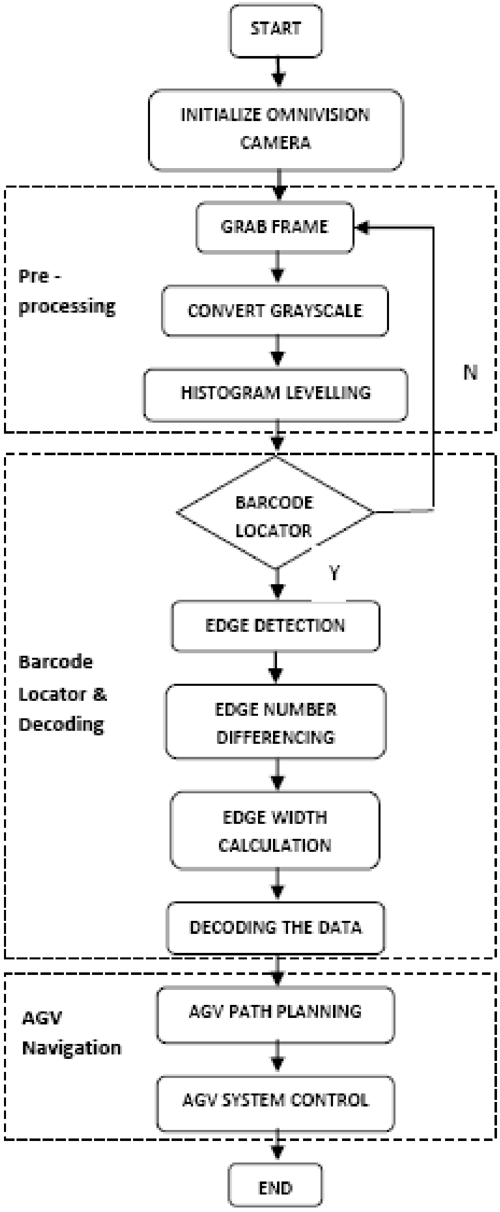

Figure 2: The algorithm

The barcode used in the experiments follows the UPC-A format. The UPC-A format consist of twelve digits number and three guard bars located at the left, right and centre of the bars. The first digit is the system character number follow by five digits data character called left hand character and another five digits data character on the right hand side. The last digit is a check character.

The barcodes sizes used in the experiments are 700 x 400 mm, 490 x 285mm, 340 x 200 mm and 230mm x 125 mm. It was printed on plain white paper to maximize the contrast between barcode and background. The maximum contrast helps in the image processing for barcode detection.

3 Experiments

The AGV used in the experiments is a mobile platform modified from Unmanned Solution. Co. Ltd. ERP-42.The detail of the mobile platform is described in table 1.

Width	470mm
Length	586mm
Height	170mm
Sensor	Omnidirectional camera
Camera height	550mm
Camera resolution	720x480 pixel
FOV Radius	206 mm
Drive train	2 DC motors with differential gears
Max speed	2.2 m/s
Operating speed	0.32 m/s
Type of controller	PC- Based
Processing software	Roborealm

Table 1: Specification of the test AGV.

The experiments were conducted in static and dynamic conditions in a warehouse. The lighting condition comes from natural light through the windows and from artificial lighting mounted overhead at about 20 meters from the floor.

The experiment is conducted in a mock manufacturing layout where the barcodes is placed strategically besides the equipment as seen in figure 3. The largest test barcode is still relatively small compared to the size of the machine.

Figure 3: AGV reading barcode in mock manufacturing floor

3.1 Static experiments

The objective of the statics experiments is to identify the detectability of the barcodes of variable sizes when the AGV is not in motion. We assumed the motion would affect the detectability and the readability of the barcode. The experiments were conducted by positioning the barcodes on the left or right sides and in front of the AGV. The barcodes were also arranged in standing or laying flat position. The result of the experiment is shown in table 2.

Barcode size (mm x mm)	Side		Front	
	Standing	Lay flat	Standing	Lay flat
700 x 400	√	√	√	√
490 x 285	√	√	X	X
340 x 200	√	√	X	X
230 x 120	X	X	X	X

(√ - detectable and readable, X – not detectable)

Table 2: Detectability and readability of barcodes when the AGV at rest.

From table 2, it can be seen that all the designated barcode sizes were detected when the barcodes are placed at the sides of the AGV. However, only barcode size 700mm x 400mm can be detected when placed in front of the AGV.

From the experiment, it can be concluded that the larger barcode size the better for detection. The larger barcode have a wider bar arrangement and can be clearly mapped into image pixels even if the image is full of noise. The detection space on the image also plays an important role as it fails to detect the front placed barcodes. As seen in figure 1, space for detection is much larger on the side of the AGV than on the front.

3.2 Dynamic experiments

In the dynamic experiments, the barcodes were aligned along the pathway of the AGV. It was found that the image processing algorithm need a longer time due to the frame rate. The slower frame rate caused the speed of the AGV to be limited to 0.32m/s in order to get useful data although the AGV is capable of moving at speeds up to 2.2m/s. The longer processing time is due to the capability of the computer processor.

The experiments were conducted with multiple runs in which the algorithm must detect and read four different barcodes located along its pathway. When the algorithm detects and read the barcodes while the AGV is in motion, a score of one was given. The score is used to evaluate the detectability and readability of the barcode when the AGV was in motion. The result of the experiments is shown in table 3.

Barcode size (mm x mm)	Score			
	Run no.1	Run no.2	Run no.3	Run no.4
700 x 400	4/4	4/4	4/4	4/4
490 x 285	3/4	2/4	3/4	4/4
340 x 200	0/4	1/4	0/4	1/4
230 x 120	0/4	0/4	0/4	0/4

Table 3: Detectability and readability of the barcodewhen the AGV is in motion.

From table 3, it can be seen that the largest size barcode scores 100% detection while the AGV is in motion. As the barcodes become smaller, the detectability and readability score becomes worse. There were no detection at all for the smallest size barcodes.

From the observation, it can therefore be concluded that in order to detect and read barcode successfully while the omnidirectional camera is in motion, the frame rate of the camera, the processing time and the size of the barcodes play important roles.

4 Conclusion

The experimental result shows that 1D barcodes can be successfully detected and read using omnidirectional camera without correcting the image distortion. The size of the barcodes is a major factor for implementation. While the AGV is in motion, video frame rate and speed contributes to successful barcodes detection and reading. Further investigation on the barcode condition such as dirty barcodes, barcodes deformation, low illumination and image noise will be conducted in future. The integration of obstacle avoidance algorithm with the proposed algorithm can be studied using single vision sensor.

Acknowledgements

This project is supported by an internal grant RDU100388, of Universiti Malaysia Pahang, Pekan, Malaysia.

References

[1] A.J. Briggs, D. Scharstein, D. Braziunas, C. Dima, P. Wall, "Mobile robot navigation using self-similar landmarks," *Proceedings of IEEE International Conference on Robotics and Automation*, **vol. 2**, pp.1428-1434 (2000)

[2] J. Huh, K. Lee, W. K. Chung, W. S. Jeong, K. K. Kim, "Mobile Robot Exploration in Indoor Environment Using Topological Structure with Invisible Barcode," *Proceeding of the 2006 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp.5265-5272, 9-15 Oct. (2006) Beijing China

[3] F. Launay, A. Ohya, S. Yuta, "A corridors Lights based Navigation System including Path Definition using Topologically Corrected Map for Indoor Mobile Robots." *Proceeding of International Conference on Robotics & Automation*, pp.3918-3923. (2002).

[4] G. Lin, X. Chen, "A robot indoor position and orientation method based on 2D barcode landmark" *Journal of Computers,***vol. 6 no. (6)**, pp. 1191-1197, (2011)

[5] W.Lin, S.Jia, T.Abe, K.Takase, "Localization of Mobile Robot based on ID Tag and WEB Camera" *Proceeding of 2004 IEEE Conference on Robotics, Automation, and Mechatronics*, pp 851-856, Singapore 1-3 December (2004).

[6] Z.Taha, J.Y. Chew, H.J.Yap, "Omnidirectional vision for mobile robot navigation" *Journal of Advanced Computational Intelligence and Intelligent Informatics*, **Vol 14 (1),** pp. 55-62 (2009)

[7] C.J. Wu, W.H. Tsai, "Location estimation for indoor autonomous vehicle navigation by omni-directional vision using circular landmarks on ceilings" *Robotics and Autonomous Systems,***volume 57, issue 5**, pp 546-555, (2009)