Obstacle Avoidance for Vision-Based Automated Guided Vehicle (AGV) Using Shortest Path Planning

Hairol Nizam Mohd Shah, Marizan Sulaiman, Syed Najib Syed Salim, Muhammad Fahmi Miskon

Faculty of Electrical Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia, Karung Berkunci 1200,
Ayer Keroh, 75450 Melaka
Tel: +60-06-555 2375 Fax: +60-06-555 2222

Abstract

This paper describes an obstacle avoidance technique for Automated Guided Vehicle (AGV). This method is based on the use of vehicle and obstacle position location; it aims to guide the vehicle to select the right path by navigating all the path areas. In this case, the shortest path is used to determine the best path direction. Before generating the shortest path, the vehicle and obstacle location are obtained from extracted objects in the image through detection, classification and tracking methods. An algorithm will find the vehicle and obstacle is also presented in this paper. One of the unique advantages of the algorithm is that the user could monitor and define the activity of AGV without going to the AGV location by looking at a control room. Besides, the user can also select and chose any location of AGV destination. By applying a real application system, manpower could be reduced as a minimum as possible. The yield target of manpower reduction in the system was achieved. In other words, it is to reduce the manpower without disturbing the output or making the same output with less manpower. The developed system has highly commercialization potential in the future.

Keywords

Obstacle Avoidance, Shortest Path Planning, Objects Detection, Object Classification, Object Tracking

Introduction

In recent years robot has become one of choice for making all jobs easier. However despite much research are important to realize it. Automated guide vehicle is one of the medium to making the human jobs easy. There are many approaches for the application automated guide vehicle to develop. How to guide the AGV by using the shortest path and obstacle avoidance in the real time is the major goal in this paper. In study of obstacle avoidance, some vision-based navigation methods for automated guide vehicle with obstacle capability have been proposed. There are several algorithms which involve the definition of the obstacle. The algorithms are objects detection, objects classification and tracking algorithms.

The information of obstacle and vehicle location is used to select the path direction. The shortest path planning algorithm is proposed. This method aims to choose the shortest distance based on critical concept which became the priority of the vehicle [6]. After all of the objects in the image are extracted, the objects are classified in to two classes namely obstacle and vehicle and the position are representative by cross symbol. The main idea in this paper is to user can monitoring vehicle activity in control unit room. This paper, focus on the step of vehicle detection and obstacle and the use of the shortest path planning.

Approach and Method

In this paper there have several method to generated and implemented the project.

Object detection

Image acquisition could be crucial for the success of the whole project and cameras can view are largest possible area [2]. To determine the larger area, the camera must mounted directly have been placed which above the selected area. How large the area defends on the height between landmarks and camera and also the focus length in the camera itself. Object detection method is used to detect the image points that compose the baseline objects, including the obstacle and the vehicle.

An object detection segmenting the image to separate the vehicles from the background is important. To be useful, the segmentation method needs to accurately separate vehicles from the background, be fast enough to operate in real time, be insensitive to lighting and weather conditions, and require a minimum amount of initialization. The technique is including the edge detection, threshold and feature extraction.

Object classification

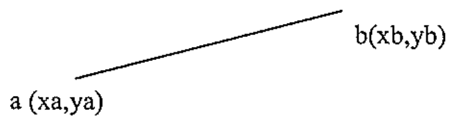
Object classification is applied after all objects in the image are detected. The main idea is to classify the object into the sufficient number of classes [2,4]. In this paper, have been used the dimension of object into two categories; vehicle and obstacle. More sophisticated shape-based technique is required. Since classification based on shape is done, the matching technique has take place. The template data is created first before matching process. The result of the dimension category is referred to the template data which satisfies either the vehicle or obstacle classes.

Object tracking

The aim of object tracking is to establish a correspondence between objects or object parts in consecutive frames and to extract temporal information about objects such as trajectory, posture, speed and direction. In this paper, the focus is on the direction and position of the object. Tracking detected objects frame by frame and compare the object image direction and position between them [4]. The difference between two frames is classified by object classification algorithms. By analyzing the object trajectory information, our tracking algorithm is able to detect and remove objects as well.

Shortest Path Planning

To find a shortest path (path planning) is a major problem and has stimulated considerable interest in modem manufacturing and other high technology fields of robotics. In the workspace, let "b" represents the moving object and "a" represents the reference point such as a path corner and junction.
The distance function is the Euclidian distance between two points "a" and "b":

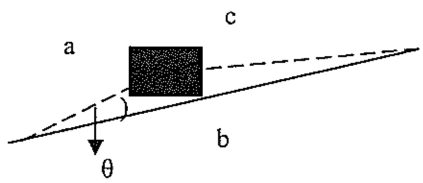


$$\text{Distance}(a, b) = \sqrt{(xa - xb)^2 + (ya - yb)^2} \qquad (1)$$

Based on the concept of the critical transition point, path planning problems can be solved. The shortest path is selected by comparing the distance of each path using the distance function.

Obstacle avoidance

The goal of the obstacle avoidance is to give an information [1] to the vehicle with the path have an obstacle. In this method, the entire of all obstacles have been calculated by using the cosines formula. In the workspace let "θ1" represents the obstacle angle and "θ2" represents the reference angle. The obstacle is defined if the $\theta 1 > \theta 2$ which the reference angle is constant 45°.



$$\theta \text{ (angle)} = \text{arc cosines } (a^2+b^2-c^2/ 2ab) \qquad (2)$$

where:

a= distance from previous junction to obstacle position

b= distance from previous junction to next junction

c= distance from next junction to obstacle position

Result

Two sets of experiment were run using all the method and approach. The first experiment consist with eight junction coordinated in enclosed 3x2 meter, obstacle-free area. The AGV was placed at the first junction coordinated in the area. In each run, the AGV was moving according the control unit instruction. The floor plan and starting locations of the AGV are shown in Figure 1. The coordinates of all the junction and AGV are represented in cross symbols as shown in Figure 2 (a) and Figure 2 (b).

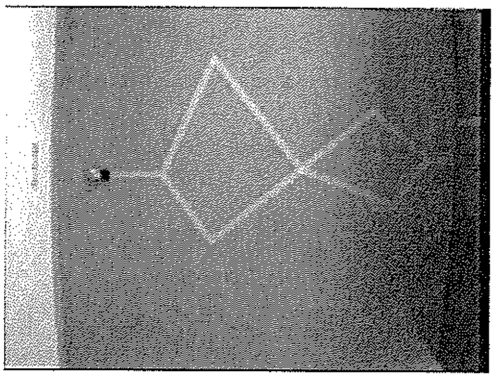


Figure 1 Frame grabber image without obstacle

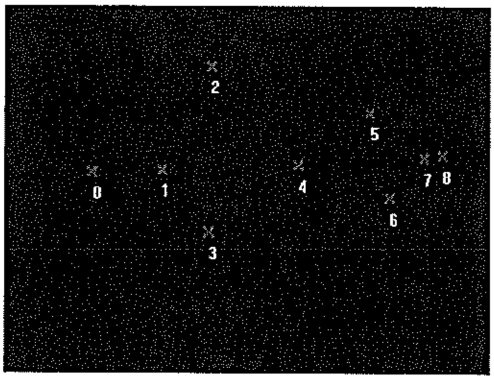


Figure 2 (a) Display screen without obstacle

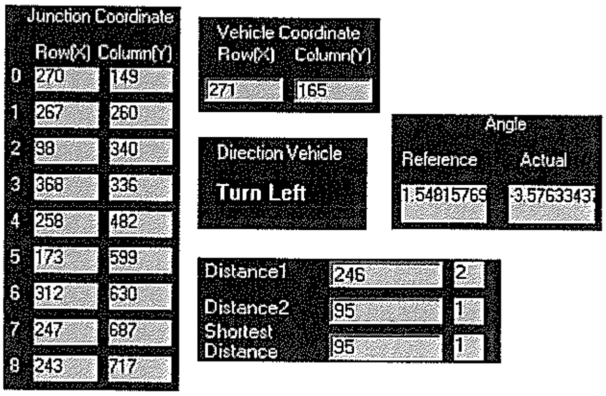


Figure 2 (b) Data processing

The second set of experiments is also same with first experiment except in this case, the layout included three obstacles. The floor plan is shown in Figure 3 and the results are presented in Figure 4 (a) and Figure 4 (b).

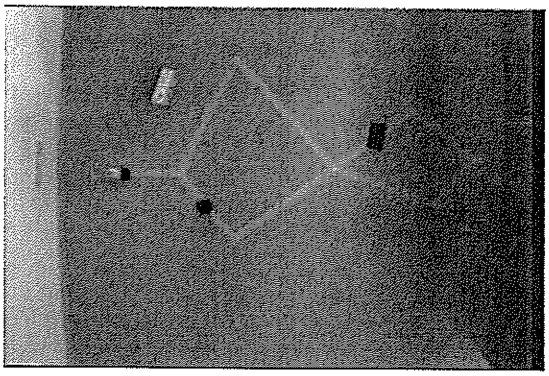


Figure 3 Frame grabber image with obstacle

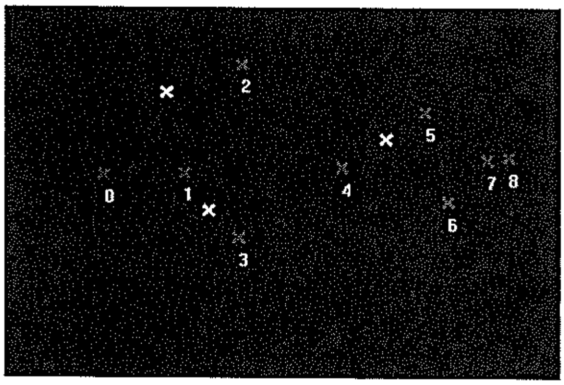


Figure 4 (a) Display screen with obstacle

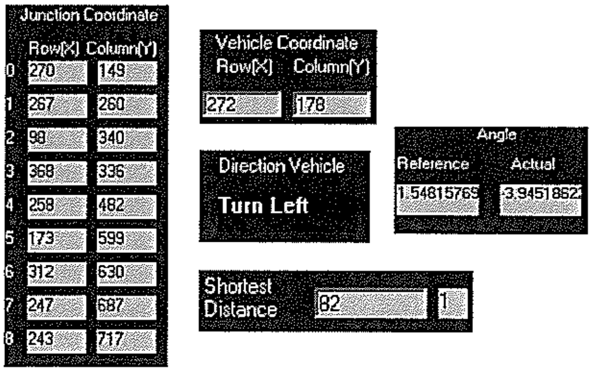


Figure 4 (b) Data Processing

Discussion

The system is constructed from several algorithms; object classification, object detection, object tracking and obstacle avoidance that include the AGV platform and a camera. There use the image processing software and integrate with visual basic programming as a medium to generated the screen layout at the control unit. The AGV platform includes the driver circuit, RF transmitter and receiver devices, battery 9V, 4 wheels and 2 Dc motor. The parallel port is use to give the instruction to AGV platform and control unit.

The visual basic is involved to integrate all programs between the image processing software and AGV. This paper only uses the image processing library in the image processing software and apply it to the application. The concept is to create template matching and to train the model at template. In the train model, first region of interest that covers the template in the training image must be specified. Only those part of the image that really significant and stable should be used for training. The template is only store the shape of object. The matching process are divide into 2 part; offline and online. The fist part comprises the train model procedure and the second part comprises the matching process itself.

During an optional test, the static image should be use as a simple image to ensure the result is cable. The illumination must be set correctly because the threshold value is deference according illumination. The threshold will affect the shape of object in the template matching procedure. Camera calibration is a first steps to doing an online application. The calibrations are included the camera height, area, camera focus and also how to converted image coordinated to word coordinated. We use the ratio between the pixel size of rectified image and unit of world coordinated of calibration of the target.

The AGV direction was defends on the comprising angle between the reference angle and actual angle. In this case, the reference angle is defined by the begin point and end of point in one path. The actual angle is defined from begin point to the AGV point in one path. Table 1 shows the detail how the desired actions are communicated with the AGV.

Table 1. AGV Actions

Condition	AGV Action
Reference Angle>Actual Angle	Turn Left
Reference Angle<Actual Angle	Turn Right
Reference Angle=Actual Angle	Forward / Straight

Conclusions and Future Work

In this paper, we presented the obstacle avoidance of vision-based automated guide vehicle using shortest path planning. There are several algorithms which involve in this paper to implement the obstacle avoidance. The image is taken in a real time from camera and processes it using object detection, object classification, object tracking and shortest path algorithms. The algorithm is related to each other to ensure the good result.

In the future work to make the system more efficient data template in object classification will be increased for obstacle. Besides that, two AGVs will be use to get the highly commercialization potential in the future. The speed and the moment of AGV movement must be considered too.

Acknowledgments

This project is sponsored by IRPA-EAR grant through KUTKM

Reference

[1] Khatib,O., Real-Time Obstacle Avoidance for Manipulators and Mobile Robots. The International Journal of Robotics Research, 5(1), 1986.

[2] Dedeoglu, Y., Moving Object Detection, Tracking and Classification or Smart Video Surveillance, Institute of Engineering and Science of Bilkent University, 2004

[3] Moore,D., A Real-World System for Human Motion Detection and Tracking. California Institute of Technology, 2003

[4] Földesy, Szatmári and Zarándy, Moving Object Tracking on Panoramic Images. Hungary Computer and Automation Research Institute of the Hungarian Academy of Sciences (MTA-SZTAKI), 1993

[5] PerS and KovaEiE, Computer Vision System for Tracking Players in Sports Games. Faculty of Electrical Engineering, University of Ljubljana. 2002

[6] Soo-Chang Pei and Ching-Long Tseng, Adaptive morphology shortest path planning based on rotating object and critical transition point, Department of Electrical Engineering National Taiwan University, 2001