VISION-BASED NAVIGATION OF AN AUTONOMOUS GUIDED VEHICLE FOR TRACKING

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ABSTRACT

This project proposes a navigation control system for an Autonomous Guided Vehicle (AGV) by detecting and recognizing line tracking with USB (Universal Serial Bus) camera. In this project a commercial robot kit, a laptop computer and a USB camera are used as the main components of the system. The use of Microsoft DirectShow technique and COM programming, the USB camera will enable the system to obtain the digital images directly without using frame grabbers. This feature makes the system more economical and compact. The vision-based navigation system structure is composed of several processes such as grabbing images, track detection, fuzzy logic controller and motor drive controller. During the navigation process, the AGV can recognize the straight and crossing track lines, detect the obstacle that might appear in the navigational path, calculate the position and orientation of the AGV. When the robot has confirmed its position and orientation, the fuzzy controller is used to keep the AGV on the track. This proposed navigation system only needs a minimum modification in implementing on any mobile robot platform that can be used in robotic research, education, laboratories, office environment and factory.

Keywords

Vision-based Autonomous Guided Vehicle, Guideline Navigation, Obstacle Detection, Fuzzy Logic Controller, Machine Vision Application.

1. INTRODUCTION

In the development of AGV, there are two main navigation systems, guiding with lines and without lines [5]. The AGV guided by lines can operate with simple design and control. If the system is equipped with computer image processing or computer vision system, it can make the design of the guiding line flexible, the guiding mark recognition easier, and system operation robust [2].

Most AGV's use various sensors such as ultrasonic sensors, infrared sensors, limit (bumper) sensors, magnetic sensors, vision system and speech recognition to accomplish their task in various circumstances. It incurs higher price on an AGV system and requires a lot of maintenance. Besides that, most systems that utilizes guided designs such as magnetic lines, requires greater maintenance and cost.

In many researches in vision-based area, a lot of techniques were introduced in its navigation system such as feedback optimal controller [3], fuzzy logic controller [4][6], neural network and interactive learning navigation [5].

In the development of V-AGV, line detection and recognition methods by image processing techniques also came to interest. Wavelet transforms and Hough Transforms are most popular for this purpose [2].

With the fast development of machine vision system and advanced computer technology, system that implements vision has many advantages compared to other systems that use different type of sensors [6]. It includes low cost in introduction and maintenance, the better and larger amount of information extracted from a single image.

This paper introduces the application of Machine Vision Software in developing a navigation control system for AGV's with fast execution, high reliability and only requires minor modifications for adjustments to be used on any platform.

This paper is organized as follows. The configuration of AGV is introduces in section 2. Section 3 details the navigation system structure that includes track and obstacle detection algorithm and controller approach. Section 4 introduces how the navigation system is integrated and result and conclusions are in section 5 and 6 respectively.

2. CONFIGURATION OF AUTONOMOUS GUIDED VEHICLE

The configuration of AGV discussed in this paper includes, an ER1 Personal Robot as a platform, Machine Vision Software, a USB camera and a laptop computer. The ER1 Personal Robot is a commercial mobile robot system that includes the control software, motor driver, aluminum beams and plastic connectors to build a chassis, two assembled nonholonomic scooter wheels powered by two stepper motors, one 360 degree rotating caster wheel, a power module and a battery (12V 5.4A). A laptop computer, Toshiba Protégé (1.2GHz, 256MB of RAM), is used as a controller device, and Windows XP Professional is loaded as the operating system. Halcon 7.0 Machine Vision system is used as image processing software and Visual Basic High Level Language will be implemented to integrated Image processing software, USB camera driver and the robot controller software.

3. NAVIGATION SYSTEM STRUCTURE

The navigation control system consists of the main components as shown in Figure 1. The low cost USB camera adhered to font ahead for accruing information such as track guideline and obstacle. Microsoft DirectShow interface is used to grab each single image in grayscale value with 320x240 pix (Width x Height) size. From the information obtained via USB Camera as inputs, the Track Detection process can then be done. Region of Interest (ROI), RGB to Grayscale conversion, Averaging technique are the techniques used in the process.

From the Track Detection process, some important data is used as inputs to the fuzzy logic controller. A lot of information can be obtained from the proposed algorithm in this paper, but only some of it is used in this project. The information obtained is used to enable the AGV to move and follow the track prepared and also detect and avoid from colliding with any obstacles.

Using Command Line Interface or socket API and Visual basic Programming, the system can control the platform of AGV directly to move it to its actual desired position. The next image will give a new position for the AGV and the process will repeat.

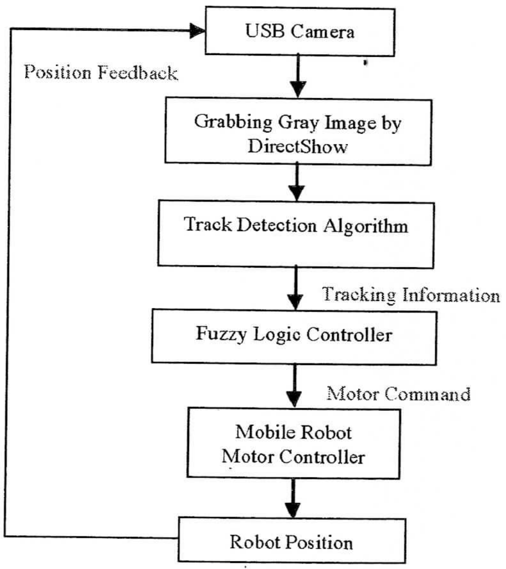

Figure 1 : Navigation Control System Structure

3.1 Track Detection Algorithm

The design of the AGV's track is shown in Figure 2. The width of the track is fixed at 1.7 cm using black cello tape with a background of white cello tape with a width of 4.8 cm. This makes the preparations for the system incur very low cost.

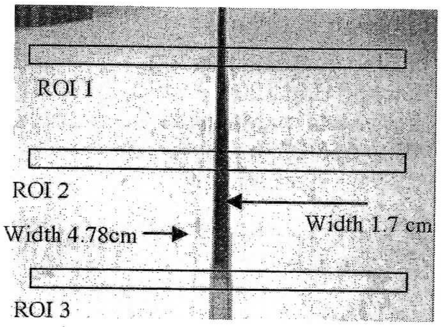

Figure 2 : Track view from USB camera

The image acquired is in low quality, with a size of 320x240 and in grey scale format. The smoothing technique by averaging with grey values of all input image is used for border treatment at the image edge. Next, the command `measure_pos (ImageMean, MeasureHandle, 2, MeasureThresholdU, 'all', 'all', RowEdgeU, ColumnEdgeU, AmplitudeU, DistanceU)` combines two important processes, edge detection and detect and measure edges threshold only applied in the ROI 1, ROI 2 and ROI 3.

The main parameter is the pixels coordinate 2,S(x,y). It is obtained from the following formula.

if (DistanceS[j] >= TWidSmin and DistanceS[j] < TWidSmax and AmplitudeS[j]<0 and AmplitudeS[j+1]>0)

so

S=[192.0, ColumnEdgeS[j+1]-(DistanceS[j]/2)]

Where *ColumnEdgeS and DistanceS* is obtained from the results of the image processing step while other parameters are fixed. The value 192.0 is the row value for the centre of ROI 3.

Furthermore, the value of pixels coordinate 1, U(x,y) can be obtained from the same formula. After that, by using values of U and S, another parameters can be calculate with simple formula such as track distance from the image centre position, type of line and track angle. The centre position of image is fixed setting by value of Width of Image divide by two.

3.2 Obstacle Detection Algorithm

In this section a simple method is used to detect an obstacle on the track while the AGV is moving. An obstacle on the track is detected by the USB camera. This paper proposes a simple approach to detect an obstacle on the track. In any case we consider obstacle appear, if track detection image prosessing cannot detect any value of pixels coordinate U and S.

When the obstacle is sensed, AGV will record data such as the width of an obstacle, and will identify the types of obstacle either cubic or flat ones. Thus, it will then stops and analyze the object located in front of it. Width of obstacle, *Distance 1* and *Distance 2* will be taken for record for future research purposes. However, methods of how to gain data on distance will not be covered in this paper. Figure 3 is an image example showing a cubic obstacle can be sensed and AGV will stop to wait for the operator to remove the obstacle.

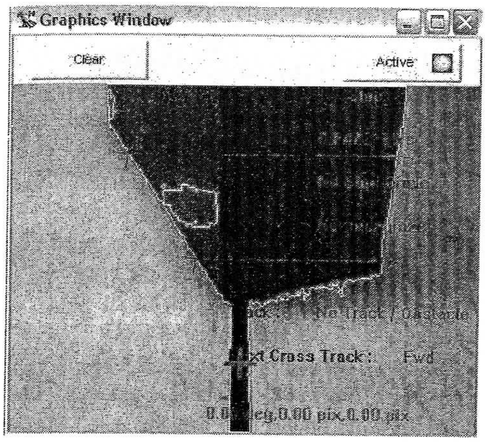

Figure 3 : Obstacle appear on the track

However, methods on how to avoid the collision of an obstacle are not covered in this paper.

3.3 Fuzzy Logic Controller Approach

To control the robot, single input and single output fuzzy logic is being applied. The values of pixel coordinate 2, S as a fuzzy input and steering angle as the fuzzy output. Set of rules of Fuzzy Logic is being shown in Table 1.

Table 1 : Fuzzy Rules Approach

IF	THAN
[S]in the Area 1	[Turn Angle] is TURNRIGHT
[S]in the Area 2	[Turn Angle] is TURNRIGHT
[S]in the Area 3	[Turn Angle] is FORWARD
[S]in the Area 4	[Turn Angle] is TURNLEFT
[S]in the Area 5	[Turn Angle] is TURNLEFT

Area 1 to Area 5 refers to the manual setting of width on the regions of image.

4. NAVIGATION SYSTEM INTEGRATION

This section is the integration of all components in Vision-Based Navigation System which is Image Processing programming, Motor Control Software and High Level Language Programming. Image processing programming needs to be translated to Visual Basic programming and some setting needs to be changed in ERI Motor Control Software.

Other aspects that must be considered for this purpose is to ensure all the settings; OS Windows API setting and local host port need to be done correctly. Exact ERI Controller Command writing are also required to ensure motor command and status request that has been done can be implemented by motor hardware.

Lastly, windows interface is needed to ease and help consumer in controlling the operation of navigation AGV system that is also not inserted in this paper.

5. RESULT

Experiment has been done on Vision-Based Navigation System and AGV could work effectively according to the prepared track. According to the screen in Figure 4 and Figure 5, this information can be obtained;

U=[x,y]=[48.0, 155.9]

S=[x,y]=[192.0,157.9]

Type of Track = Straight

Image Processing Time : 45ms

Track angle = 0.07 deg

Track distance for ROI 1 =-1.01 pix

Track distance for ROI 2 = -2.06 pix

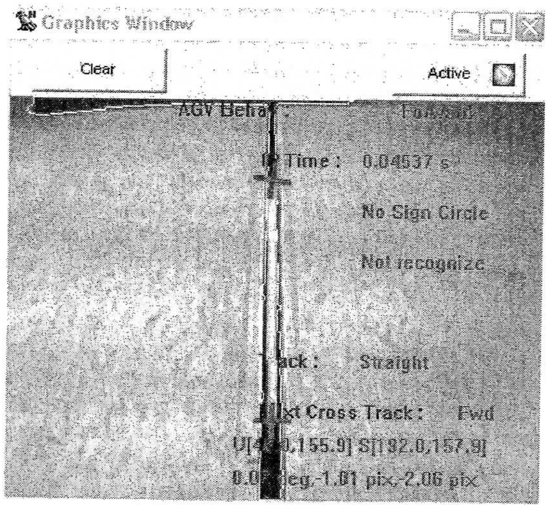

Figure 4 : Image form USB camera and parameters display

Control Variables:

TrackAngle:	0.0725493250522
TrackDistanceU:	-1.00650253296
TrackDistanceS:	-2.06413269043
CircleSignExits:	0
SignType:	0
CrossDet:	0
NumSignDet:	0
RowEdgeU:	[48, 48]
ColumnEdgeU:	[152.54296875, 159.244018555]
AmplitudeU:	[-155.575012207, 155.8699646]
DistanceU:	6.70104217529
ResultU:	?
ResultDistanc~:	1
RowEdgeU_Up:	[48, 48]
DistanceU_Up:	6.70104217529
ColumnEdgeU~:	[152.54296875, 159.244018555]
RowEdgeS:	[192, 192]
ColumnEdgeS:	[151.440109253, 164.431625366]
AmplitudeS:	[-163.834335327, 163.525177002]
DistanceS:	12.9915161133
ResultS:	?

Figure 5 : Navigation data result sample

6. CONCLUSION

This paper has given tally description of a Vision-Based navigation system for an AGV. Using ERI Commercial Robot Kit as the platform, image taken from USB camera is analyzed using certain techniques of image processing. Introducing USB camera in the system with the applied technique, although the image obtained would have lower quality effect, is sufficient to trace back the prepared track and gaining other information that is crucial such as tracing back crossing track, intermittent track and tracing back the existence of obstacle in the path. Next, the data obtained from the image can be analyzed by using track detection algorithm that has been proposed to get the current position and AGV orientation that enables AGV to follow the centre line on the track using a fuzzy controller method. Using this method, AGV can move to follow the track successfully. Also, by using single sensor (USB camera) can detect and measure the width of obstacle and can stop to prevent collision. Further study regarding this paper is still in progress, which focuses on Navigation Intelligent system including speed controller, path planning strategy and collision avoidance algorithm.

7. ACKNOWLEDGMENTS

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