Automatic Guided Vehicle Control by Vision System

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Abstract - **AGV's control has been developed in several types. This research aims to develop the AGV's control using image processing in order to assist AGV from losing the way when the guide line is missing. The AGV, used for experiment, has three wheels. There are one wheel at the front and another two rear wheels. The front wheel is driving and steering controlled by using DC motors on each axis. An encoder is attached on steering axis which is used to check AGV orientation angle. At two rear wheels, there are also attached encoder which is used to measuring the position of AGV for controlling distance of the AGV motion. PLC is applied for AGV's control application. Wireless color CCD camera is used to be a sensor for detection line's color that is placed on the ground which is the front side of AGV. CCD sensor is applied to navigate the detected path of traveling. Red line is constructed for AGV's path. Image processing is operated for detecting the different of guide line and background. Laplacian operator method is applied for edge detection algorithm including filter and thresholding technique. Computer program will created the virtual line by using trigonometry method and sent current position data to AGV's motion controller.**

Keywords – **Automatic Guided Vehicle, Image processing, Laplacian operator**

I. INTRODUCTION

The field of machine vision, computer vision, and image processing is quite similar, but different are the technique of processing and their applications. Most of researches were applied to applications in autonomous systems such as intelligent robotics, Unman Arial Vehicle (UAV), and under water robotics, etc. Beyond these applications a few of research attempted to develop a new application for industry such as an Automatic Guided Vehicle (AGV), forklift truck and so on. AGV has developed for industrial purpose of Thailand initially refereed to [1-4]. In the literature review, we found that [5] applied vision based navigation and landing for rotorcraft and [6] employed computer vision to lateral control of aircraft to following the road lane. Comparison of controller performance is obtained by LQG and RHC control technique. Both applications in [5-6] were done only simulation results. In applications of intelligent robot, several techniques of vision based vehicle localization were explained in [7-8]. Viewing corridors with right parallelepipeds are used for routing of robot. Lateral position and orientation of robot are obtained by coordinate transformation technique. The other localization techniques of robot proposed by [8] with the simultaneous localization and mapping (SLAM) with stereo vision. Technique of this research was adopted the popular sequential Monte Carlo algorithm, Rao-Blackwellised particle filter to explore the multiple hypotheses. Both papers are also showed only simulation results. In addition the navigation through corridors and narrow local occupancy was done by [9], but the purpose of this research was interested on the simplicity of implement. The final goal derived from local grid path finder algorithm. But the drawback of this research is that the robot cannot avoid obstacle and largely error of control system due to mechanical aspects. [10] explained the control of fleet of a robot with five control layer structures, but the results of experiment are not sharply concluded. In this research we currently consider about the applications for industries. The Automatic Guided Vehicle (AGV) is one choice for automation for manufacturing system. Other automations are included material handling transported by conveyor, forklift truck [11] and other applications. [11] applied computer vision for control the intelligent forklift truck, but the system still not explained the processing of vision operation. Whenever [12] proposed the algorithm of new lane detection for autonomous vehicle by computer vision, paper is mentioned only the detection algorithm and simulation results, but they did not test and reveal their objective to a real vehicle. Although [13] developed the embedded vehicular controller based on vision system to control AGV, the proposed controller still slowly reached to tracking the path and error of tracking still largely. So our research objective is differed from the previous research in the literature reviews, we propose the methodology for solving the problem of fleet floor level command of AGV applied to manufacturing systems.

II. SYSTEM ARCHITECTURE

The AGV prototype design is based on existing JUMBO industrial truck as shown in Fig. 1. It is a three wheels vehicle as shown in Fig. 2. The front wheel is used for driving and steering the AGV and the two rear wheels are free and equipped with encoders. The steering and driving are DC motors. Two encoders are individually attached on the two rear wheels in order to measure the vehicle displacement and then calculate its real time position and orientation. The choice of positioning the encoders on the free wheels provides to the vehicle an

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accurate measurement of its progression. A programmable logic control (PLC) is used for motion control.

Fig. 1. Photo of the AGV prototype

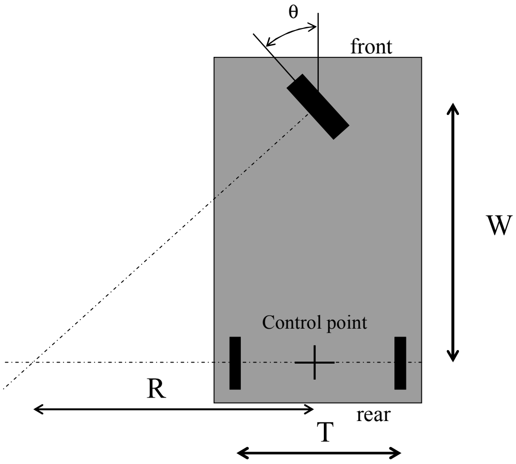


Fig. 2. AGV prototype structure

The parameters of the motion are driving speed and steering angle which determine the evolution of the position and orientation of the AGV. The input and output signal are interfaced with PLC module. The inputs are the encoder signal from left and right rear wheels. The driving speed and steering angle are calculated form these inputs and the digital output is converted to analog signal to drive amplifier of the driving motor and steering motor on front wheel as shown in Fig. 3.

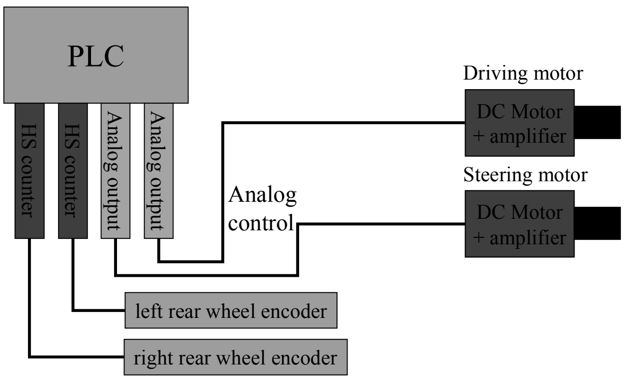


Fig. 3. AGV prototype command architecture

II. IMAGE PROCESSING TECHNIQUE

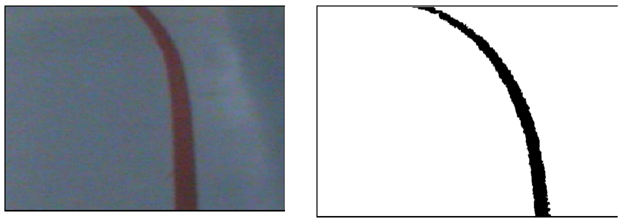
A. Filtering and Thresholding

From image acquisition, filtering is an important operation technique for image processing, since vision sensing element is mostly sensitive to light source. Image filtering is applied the convolution of input image and convolution kernel of matrix by masking of both with linear filter as obtained by (1).

$$G(u,v) = F(u,v) * H(u,v) \tag{1}$$

Where $G(u,v)$ is the output of image filtering, $F(u,v)$ is the input of image filtering, and $H(u,v)$ is the convolution kernel for masking.

Thresholding is applied to transform the image intensity level to binary level. It uses to classify the background and the interest image. The filter and thresholding of an image is illustrated in Fig. 4.



a). b).

Fig. 4. Filtering and thresholding of image a). Original image and b). After filter and thresholding process

B. Edge Detection

Edge detection is obtained by the second order Laplacian operator by (2).

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \tag{2}$$

The output gradient of image is derived by partial derivative. The representation of image coordinate is measured at center of interested image in spatial domain as indicated in (3) and (4) respectively. The result of edge detection is depicted in Fig. 5. In the study we found that Laplacian operator is more effectively than other principles.

$$\frac{\partial^2 f}{\partial x^2} = f[i, j+1] - 2f[i, j] + f[i, j-1] \tag{3}$$

$$\frac{\partial^2 f}{\partial y^2} = f[i+1, j] - 2f[i, j] + f[i-1, j] \tag{4}$$

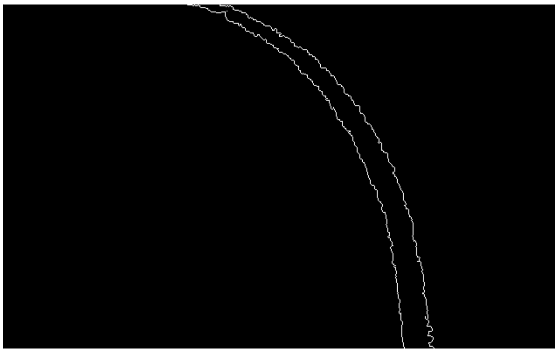


Fig. 5. Result of edge detection of path

C. Path Determination

Update of path of travelling of AGV is calculated by the principle of trigonometry as shown in Fig. 6 to transform from (x-y) coordinate to (R,θ) coordinate system. The derivation of parameters is derived by (5-7).

$$R^2 = (R\cos\theta - y)^2 + x^2 \quad (5)$$

$$R^2 = R^2\cos\theta - 2Ry + y^2 + x^2 \quad (6)$$

$$y^2 - 2Ry + x^2 = 0 \quad (7)$$

Replacing x and R we can obtain y from (7).

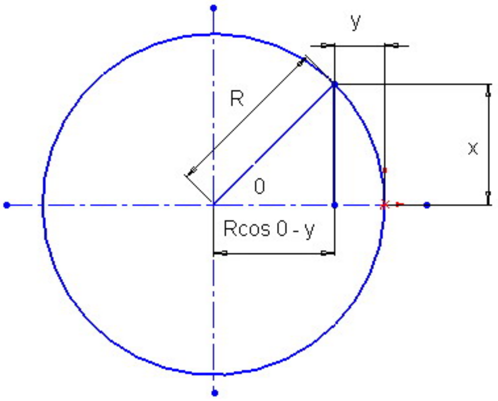


Fig. 6. Path determination

D. Algorithm for Path Finder

As depicted in Fig. 7-8, if the path of travelling of AGV is discontinuously of guided line, normally AGV will losing the way. But in this case, the AGV must be decision to move crossing the discontinuous path to the target with true direction. To solve this problem, we present the algorithm to find the true path obtained as follows:

START:

$$L1 = f(x,y) + 1 > 0 \quad (8)$$

L1 = *distance of x-y coordinates at starting point*

f(x,y) = *function of x-y coordinate position of pixel matrix*

If L1 < Lmax , *Then calculates (9)*

$$L2 = f(x,y) + 1 > 0 \quad (9)$$

L2= distance of x-y coordinates at second point

f(x,y) = *function of x-y coordinate position of pixel matrix*

If L2 < Lmax , *Then calculates (10)*

If L1 > L2

$$\theta = \tan^{-1}\left(\frac{y}{-x}\right) \quad (10)$$

(Turn Left Action)

If L1 < L2

$$\theta = \tan^{-1}\left(\frac{y}{x}\right) \quad (11)$$

(Turn Right Action)

If condition is not satisfied with (9), (10), (11), then calculates (12).

$$L3 = f(x,y) + 1 > 0 \quad (12)$$

L2= distance of x-y coordinates at third point

f(x,y) = *function of x-y coordinate position of pixel matrix*

If L3 < Lmax , *then find out* R *and* y *by (8) and (12),*

Otherwise if L1 > L3 , *then determine* R *and* y *by (10)*

and if L1 > L3 , *then determine* R *and* y *by (11).*

END

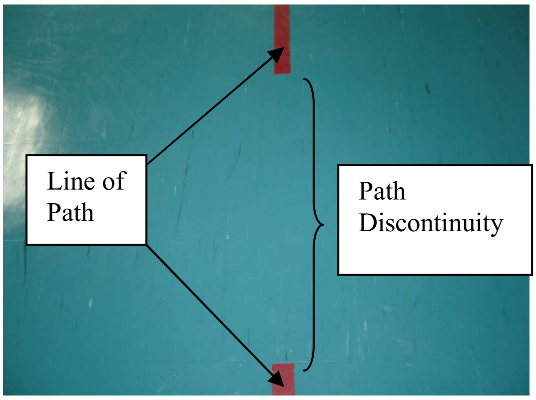


Fig. 7. AGV's path discontinuity

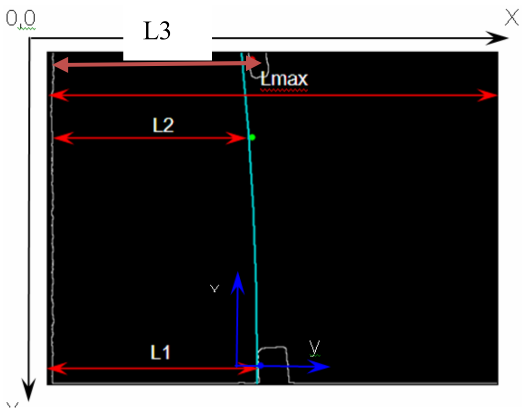


Fig. 8. Command of AGV's decision making

IV. EXPERIMENT RESULTS

In experiment, we tested in several tests of AGV navigation based on vision system. Straight line path and curvature path are conducted in this experiment with image perception and guided AGV to specified guided path. The experiment result is illustrated in Fig. 9 for AGV output navigation in x-y coordinate displayed on computer. It shows that the AGV can move along with the designated path and with the discontinuous path in smooth motion. AGV can move from starting position to final position on specified path in x-y coordinate. We can conclude that vision based guidance for AGV can be applicable in the shop floor manufacturing system, although guided path is not effectively obtained the meaningful information.

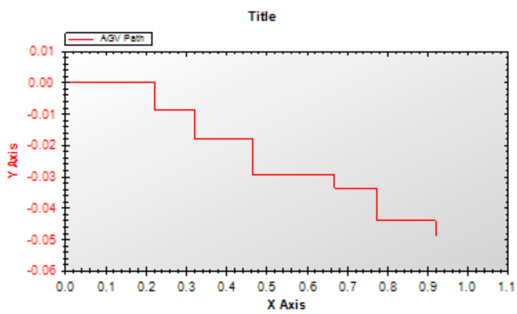


Fig. 9. Result of AGV motion with along defined path

V. CONCLUSION

In this research we describe the system structure in the early design stage. The main ideal of this paper is represented the applied vision based navigation system. The image processing is carried out to convey the AGV's guided lining. Laplacian operator is adopted for edge detection of guide path including filter and thresholding of image operation. Although the path is not cleared or discontinued of guide line, AGV still find the way to move to the target generated the controlling AGV' path with the simple trigonometry methods. The experiment reveals that AGV can move from starting position to reach the goal position successfully by vision guidance system. The proposed architecture and control algorithm attempt to use for the real applications in shop floor level.

ACKNOWLEDGMENT

The authors would like to thank the Schneider electric for Automation solution and JUMBO, industrial trucks manufacturer, to support the AGV prototype construction.

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