The Edge Distribution Function Based Method of Trajectory Tracking for AGV

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Abstract: We developed an machine vision method for navigation control of a traveling automatic guided vehicle(AGV) on desired trajectory with guided marks. The formulated EDF accumulates the edge magnitude for edge directions. The EDF has distinctive peak points at the vicinity of trajectory directions due to the directional and the positional continuities of desired trajectory. Examining the EDF by its shape parameters of the local maxima and symmetry axis results in identifying whether or not change in traveling direction of an AGV has occurred. Simulation results show that the presented method is useful for navigation control of AGV.

Keywords: AGV, edge distribution function(EDF), Navigation control, Image processing

1. INTRODUCTION

Recently, from the advanced foreign nation for the heightening of competitiveness of the harbor logistics positively it propels an automation container terminal development with 21 century future harbor industries. It follows hereupon, the future intention harbor development which possesses an high-tech even from our country it leads and that expense the Northeast Asia logistics center which is competitive power of efficiency and it constructs it sleeps,, the spur in the focus engineering development for the container terminal automation cargo work which is necessary to an automation container terminal development, the waybill rain and the integrated operation it inflicts.

Specially, in order to transfer with intelligence AGV the research which is active is being advanced the transportation work of the inner wall which is a work where the most many personnel become disturbance from the container terminal operation and yard for export, income and the exchange container. For the transfer with of intelligence AGV the technique of navigation control, main system, obstacle perception system and the communication system back of the AGV does to harmonize composition.

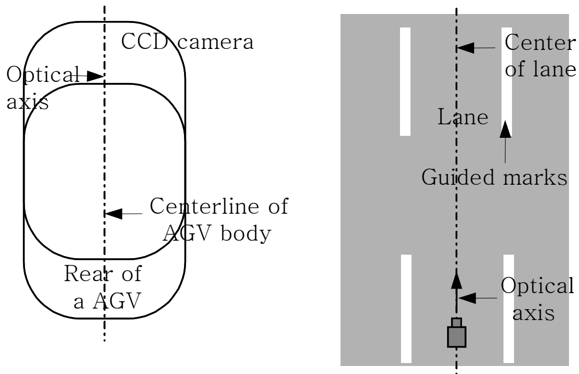
For the environmental awareness and navigation of the AGV it will affix the camera from the dissertation which it sees, the guided marks or taping on the bottom and it will reach and it follows and against the semi-fixed course method which travels it shows. It is a method which has an each advantage at interim step of fixed-course method and auto-navigation method. Namely, laying work of sensor module will see without to be easy the change of the course to be possible, also image processing of the navigation guided marks it will lead and the absolute location of oneself it will be able to revise.

In order for the AGV to follow with an aim location from current position the speed and location control are necessary. The speed control gives from the drive and department in order to travel with a position speed adding and subtracting belonging that speed it follows. The other side, the location control must calculate a speed and angular velocity from the navigation controller. The location control is control command of high position phase of speed control, for the calculation of speed and angular velocity essentially must recognize the relation location of the AGV from the detection of the guided marks and navigation course[1][2].

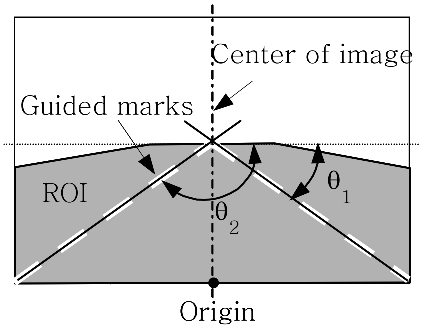
For the location control of the AGV in order to recognize the relation location of detection and the AGV of the guided marks which it does in necessity road image analysis it leads from the dissertation which it sees and the edge distribution function(the EDF and Edge Distribution Function) which is it is applied in lane disconnection alert system it applies. Analysis of the EDF it leads and it gets and location and direction information of the guided marks position the application is possible in relation location recognition of the AGV, it do proof by simulation.

2. ALGORITHM OUTLINE

In the paper we propose the AGV navigation. The vehicle mounted the CCD camera on the center of top as shown the Fig. 1(a). The AGV navigates the center of the guided marks Fig. 1(b), the image which it acquires (the Fig. 1(c)) real-time process, it gets, direction information θ_1 and θ_2 of the guided marks it uses the information and currently it calculates navigation information of location and direction of the AGV. The control part uses this information and it controls navigation of the AGV. Information θ_1 and θ_2 used in the navigation is extracted from the EDF, this function shows the histogram of the edge size which relates in the direction angle of the edge.



(a) (b)



(c)

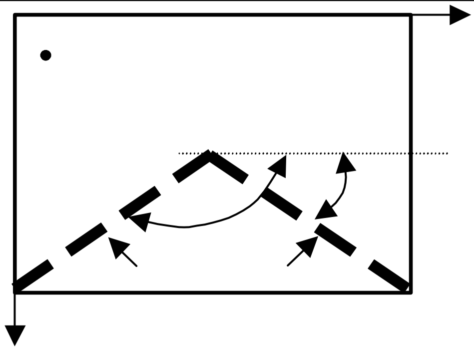
Fig. 1 The basics of AGV navigation: (a) Camera installation on AGV (b) Description of the relationship of a CCD camera and trajectory with guided marks, (b) Orientations and positions of trajectory boundaries, and ROI for image processing.

2.1 EDF(edge distribution function)

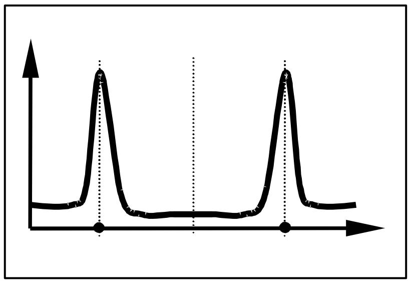
The course induction traveling method which uses the CCD camera which is proposed from the dissertation which it must painting or taping of the guided marks in two condition lower part and must be established. First, guided marks must be painting or taping in brightening rather then road. Second, the direction and location of the navigation mark do not change suddenly and to be must have continuity. Like this condition satisfied two fact whose what kind of a noise or a mark is like this continuously is because rare where the AGV is operated. The right and left guided marks will be able to assume a parallel is establishment condition with two conditions against the establishment of the guided marks. By the restricted condition which relates in the assumption and the camera establishment the marks direction of the image which it gets from the center of navigation guidance marks accomplishes symmetry in the 90°. To ratiocinate the fact where the bases of becomes like this condition simultaneously it defined the one-dimension discrete function regarding edge direction in this paper.

$$F(\theta) = \sum_{n(\theta)} \nabla f(x, y) \tag{1}$$

$n(\theta)$ is a number of the edge pixel which is an edge direction from here, $\nabla f(x, y)$ shows an edge size of Eq. (1). Here, in order to get $n(\theta)$ it defined edge direction $\alpha(x, y)$ from 0° between 180°, quantize it by 1°. When it accumulates the size of edge pixel which has the direction with that it shows in Fig. 2 as one-dimension edge distribution function (EDF) comes to get together.



(a)



(b)

Fig. 2 EDF: (a) Image coordinate and trajectory boundaries, (b) EDF.

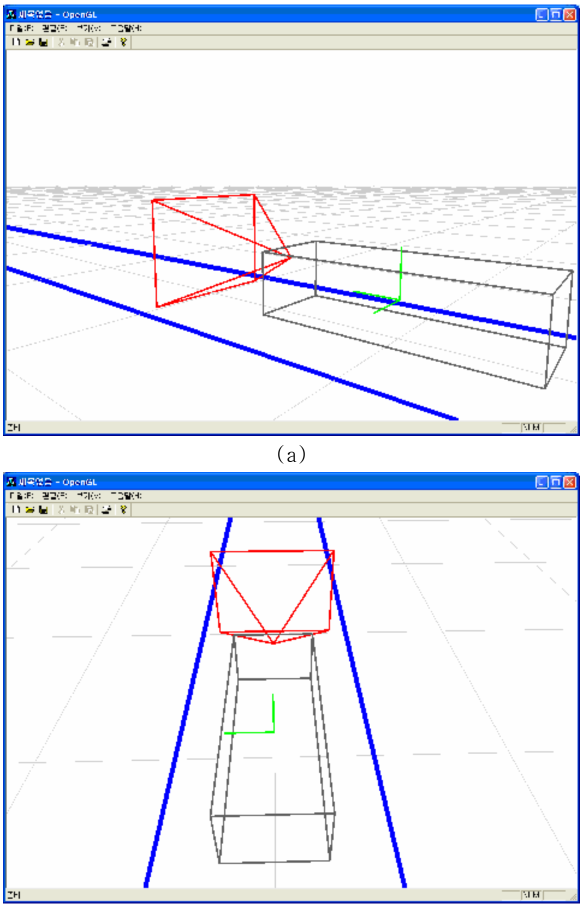
When we observe the shape of the EDF, we can find two important characteristics. First, it has a large value near the angle which corresponds to the direction of the traveling guided marks. The reason is that the course of traveling path has continuity without sudden change but the object without traveling guidance mark doesn’t have these characteristic. Consequently, EDF has partial maximum values in right and left side which have a boundary at 90°. Second, when light axis of CCD camera in AGV is located in the center of traveling path, EDF has symmetric characteristics as a center near 90°. The partial maximum value of EDF is prediction value of traveling path direction because it is same as the direction of the traveling path. Especially, EDF has symmetric form, this characteristic is used for solution of side location control problem in AGV. When we use the fact that symmetric form of EDF can not maintain the center near 90° at the traveling path escape from center, the problem of side control problem in AGV can be solved without forming template or adaptive control.

2.2 Trajectory Tracking and EDF

The EDF which is defined in this paper could be directly applied to course induction traveling of the AGV. The relative location measurement between AGV and traveling guided marks is well known method for course induction traveling of the AGV. It depends on localization of traveling guided marks for getting valuables which is located in the center of traveling path and center axis. It seems be simple but it needs camera compensation, and it should change the input value frequently when the width of AGV and the width of traveling path and the location of camera are changed. In addition, the detection of the traveling path means exact location recognition of the traveling guided marks, so we can't assume the traveling path when location error is detected. The EDF that is defined in this paper can strongly realize path inducement traveling algorithm. So we don't need camera compensation and location recognition of traveling guided marks and geometrical modeling between traveling path and camera, which was difficult in existing research. The basic idea is that the gradients of right and left traveling guidance mark are changed together when the traveling location of AGV in traveling path is changed. So, if we detect the gradient change of traveling guidance mark, we can control it from present location to target location.

3. PATH INDUCEMENT TRAVELING SIMULATION AND CONCLUSION

Fig. 3 is the simulation which is the possibility of path inducement traveling using EDF. Fig. 3(a) and (b) show traveling guidance mark and the relationship between the camera in AGV and the coordinate system. We represent traveling guidance mark as a line, and we have realized it using OpenGL library in visual C++.

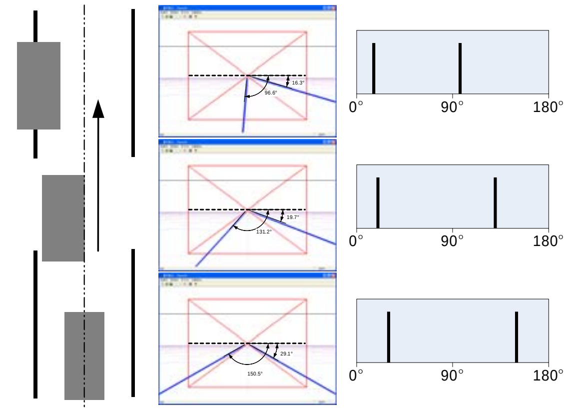


(a)

(b)

Fig. 3 Simulations of navigation control.

The simulation of escape from center to left side in AGV is shown in Fig. 4. Fig. 4(b) and (c) show traveling guided marks in the image and partial maximum value of the EDF which it constructs with one-dimension. The Fig. 5 shows the simulation of the escape to right side. When we observe the dotted line, we can find that the partial maximum value of the EDF is changed a lot. Namely, there is big gradient change at the boundary of the path guided marks and when AGV comes to boundary of right side, we can find that the gradient change of right side θ_2 gets bigger than left side. Consequently, the EDF depicts the slope change of the guided marks boundary in input image well and can detect symmetry axis. So, if we analyze EDF, we can make path guidance traveling of AGV strongly.



(a) (b) (c)

Fig. 4 Navigation control of AGV: (a) Departure to left trajectory boundaries, (b) Changes in orientation and position of guided marks when an AGV approaches the left trajectory boundary, (c) EDF.

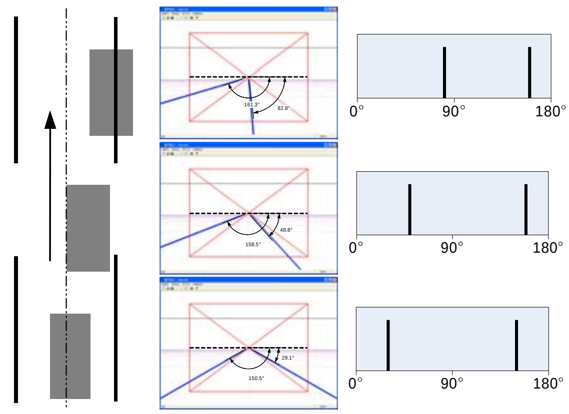


Fig. 5 Navigation control of AGV: (a) Departure to right trajectory boundaries, (b) Changes in orientation and position of guided marks when an AGV approaches the right trajectory boundary, (c) EDF.

The course where the AGV will move is coming to make in advance, generally becomes the expression at entire area coordinate total. And, with the fact that it shows in course following hour picture 6 together the AGV to know the rectilinear course which is connected with a right angle and to consider the rotary radius back of the AGV that it follows like that with soft curve, to the rectilinear course previously on the next rectilinear course penetration hour in order to enter, it includes a disconnection point A and it creates the course [4][5][6]. In this paper, for course induction traveling of the AGV the EDF which is proposed it will be able to apply even at traveling hour of the curve course where the disconnection point A is included. This under restricted conditions of the camera regards as the straight line even in case of the curve course and the control is possible. If when the each EDF to the curve traveling course one case which is sudden it divides an image control territory and it constructs, also the curve detection is possible.

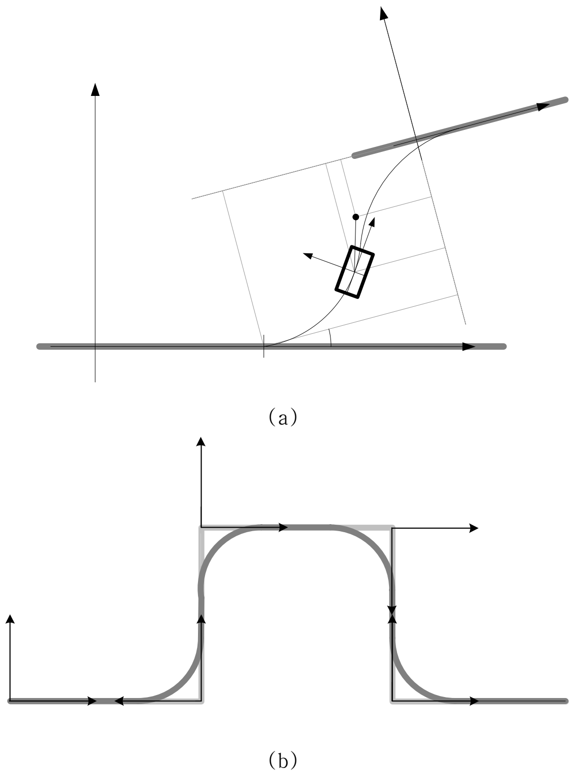


Fig. 5 Navigation of AGV: (a) Navigation of AGV on path {S}, (b) Paths including exit point e.

4. CONCLUDE

In this paper, we applied EDF by image processing for navigation of AGV. From the dissertation which it sees course induction travelling of the AGV hazard image control it led and the edge distribution function which is constructed (EDF) it applied. The EDF in location control of the AGV calculation of essential speed and angular velocity it provides the location and direction angular information of guided marks and from the traveling course relation location of the AGV it is tough and it will be able to recognize. Trajectory tracking which uses the EDF only the rectilinear course the bay knows the disconnection point e was included application is possible with until soft curve. Also EDF analysis it leads and it gets and location and direction angular information of the guided marks position the application is possible even with attitude revision of the AGV.

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