International Journal of Control and Automation
Vol.10, No.6 (2017), pp.187-194
http://dx.doi.org/10.14257/ijca.2017.10.6.18

Smart Unmanned Logistics Management System Utilizing Multi-Threaded Implementation

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Abstract

It is possible to control the moving of the forklift based on the distribution of the information conveyed through the communication between the atmega128 and laptop using Bluetooth. Recognition of the obstacles, recognized obstacle through ultrasonic sensor it is determined whether within the specified distance, and implements according to the recognition processing operations. This paper present Lane Departure Warning Algorithm with real-time processing based on Computer Vision. To process in real-time, it needs a simple and efficient algorithm. The main idea presented in this paper is, 1) to set the Region of Interest (ROI) to reduce calculation area, 2) to use the first derivation in horizontal and vertical direction, rather than using Sobel or Canny edge detection which is the second derivation, to boost calculation speed. To extract road lane with high accuracy HSV Color space conversion and segmentation were used. Hough transform and special filtering was used to detect lines. Experimental results on different road scenes indicate the good performance of the proposed method, especially in noise control and real-time processing.

Keywords*: Lane Detection, Hough transform, Region of Interest (ROI), HSV color space, MultiThreshold, atmega128, Bluetooth*

1. Introduction

Forklifts and transportation vehicles for loading and transporting raw materials and products on racks at industrial sites and warehouses are important factors of the logistics system. However, due to industrial accidents from forklifts in hazardous worksites and radioactive wastes, the work environment inhibiting men to operate forklifts is rapidly increasing. Studies on unmanned technologies of forklifts and transportation vehicles are continuing to reduce environmental and industrial accidents in the hazardous work environment.

For example, an unmanned pallet truck loads a pallet by the operator and automatically moves along the predefined route by the embedded guide wire or paint strip on the floor. Especially, unmanned forklifts capable of automatically loading and transporting pallets were developed from the advanced technology for unmanned driving vision and localization system and applied throughout industry fields.

Moving unmanned forklift requires various element technologies.

First, we need a technology for detecting the location of the forklift. Especially, as forklifts are widely used in indoor as well as outdoor environments, we need a location detection system suitable for the indoor environment.

ISSN: 2005-4297 IJCA

Second, as unmanned forklifts conduct tasks according to human instruction and move to a specific location, we need the actuator controlling technology that moves the forklifts.

Third, we need vision technology for forklifts to detect the coordinate for loading pallets.

Fourth, we need the map building and path planning technology for forklifts to move to specific locations. Fifth, we need the technology for forklifts to detect and divert from obstacles from driving along a predetermined route.

Lastly, we need measuring technology using a sensor that detects obstacles or measures the height of the fork.

In the future, we will need technologies for allocating duties to each forklift in a collaboration of multiple forklifts.

2. Study Content and Method

A. Implementation of Communication System:

The most important purpose of this study on the unmanned forklift is to determine whether to allow the atmega128 to process the main task or to command all databases and forklifts by having an external server via communication.

From this, the future development in light of expandability, protocol issue, availability of communication and multiple communications of two or more forklifts, we decided to have an external server using the Bluetooth communication method. A laptop with Intel ® Centrino ® Wireless Bluetooth ® 4.0 and a high-speed adapter was used for one-on-one communication with atmega128 using hc-06, the serial communication API via C++ was used for development environment and for the database, the data processing and linked list data using the priority queue method are stored.

In conducting Bluetooth communication, the biggest issue was that the communication method of atmega128 was 8-bit. As atmega128 does not have a separate communication buffer, there was a potential problem in communicating with the laptop which served the main server. While one option utilized the built-in memory of atmega128, we decided to have a separate protocol to process at the atmega128 coding level, which resulted in improvement in the overloading and processing speed of atmega128.

B. Implementation of Obstacle Detection System:

In this study, to detect obstacles, an ultrasonic sensor is connected in front of the forklift to distinguish the presence and absence of an obstacle in a predefined distance. The formula for the distance to the obstacle becomes 34,530 cm/s for the propagation velocity of the ultrasonic wave at room temperature and the inverse of time taken to progress 1 cm, which is 28.96 x 10E-6 s/cm. The distance determined from this formula was used for detecting an obstacle, the minimum detection distance of the obstacle was configured at under 5 cm, and the direction of progress of the forklift was configured to reverse once an obstacle is detected.

C. Implementation of Evasion and Track Operation Algorithm

In this study, the drawer for loading on a 4x4 track was designed in 4x2. On the main server, an array of 4x4 was allocated, and to represent the state of the track line on each array, the status of each array was made into another four arrays to have 0 if there is an obstacle on each line or 1 if there is none. Therefore, when the status of the forklift line is queried to the server via communication, the state of line in this array is investigated and then conducted after confirmation.

D. Preprocessing

To accurately extract only the lines, the closed morphology was used to eliminate the ROI set up noise, and to have more linear forms when extracting the edge. By doing this, we could eliminate much holes inside lines and reduce errors from holes when extracting edges.

From the image after morphology, to extract an edge, differentiation was conducted in the initial horizontal y vertical direction. While it is advisable to use Sobel or Canny Edge extracted function, as it will take a long time for secondary differentiation, horizontal y vertical differentiation that can be easily calculated using initial differentiation was conducted.

E. Hough Transform

In this study, the linear line was found by conducting Hough transformation based on the pretreated image. Hough transformation is based on the simple idea that all linear lines can be expressed by $y = ax + b$. In other words, it can be expressed by formulas such as $b = x_i a + y_i$ on parameter spaces a and b.

This straight line of interest can be filtered based on the slope of that straight line by finding the equation for the straight line. Because the traffic lane will not dramatically change within a set radius of the curvature limit, the line found horizontally near the slope of 0 will be filtered.

Also, as there are traffic lanes with positive (+) slopes based on the center of the image and lanes with negative (-) slopes, the slope of the straight line is restricted by a certain amount to find only the straight line Hough transformed in the relevant part. In parameter spaces a and b, the straight line is expressed in a single point. However, as processing this method is difficult with the slope approaching infinity, to overcome this limitation, it's transformed into a regular method of expression.

$$p = Xcos\theta + Ysin\theta \quad (1)$$

The value of (p, θ) detected from each pixel of the image from the algorithm of 'function (1)' is added to the accumulation table and the (p_{max}, θ_{max}) with the maximum value among the accumulated values can be inversely transformed to extract the straight line.

F. Extraction of Forklift Route Lane

Even after finding the straight line using Hough transformation, we still have the noise issue. This is mainly due to the road codes and peripheral environment in the same color as the traffic lane. To resolve this, we need to extract only the straight line of interest only. This line of interest can be found by using the equation for the straight line and filtering based on the slope of this straight line. As the traffic lane will not dramatically change within the set radius of the curvature limit, filter the straight line found horizontally with a slope close to 0. Also, as there are traffic lanes with positive (+) slopes and negative (-) slopes based on the center of the image, restrict the slope of the straight line by a certain amount to find only the Hough transformed straight lines.

G. Extraction of Center Line and Detection of Error

The center line of the vehicle can be extracted based on the representative straight lines on each side. This can be done as follows:

① Find the x points where y=50 for the representative straight lines on each side and connect.
② Find the Bisection point at the center of the connected line.
③ As the center point of the vehicle is the center point of the ROI area, connect the center point with the x point from ② to make the center point for the vehicle.

Make the center point for the vehicle in the above method and calculate the locations of the wrong lines and traffic lines to determine the lane departure. Lane departure means that the vehicle has diverted beyond the lane, hence the center line for the vehicle must be closer to the traffic lane. This phenomenon does not occur during normal operation or operation on a curve and hence is adequate for determining the lane departure.

3. Experiment Result

The thickness of the acrylic board used was 5 mm. White and black lines were made to distinguish from each other. A total of 6 overlapping quadruple lanes were made. The actual space for loading was designed in a 'T' shape with 3 storages approximately 1 m in total length.

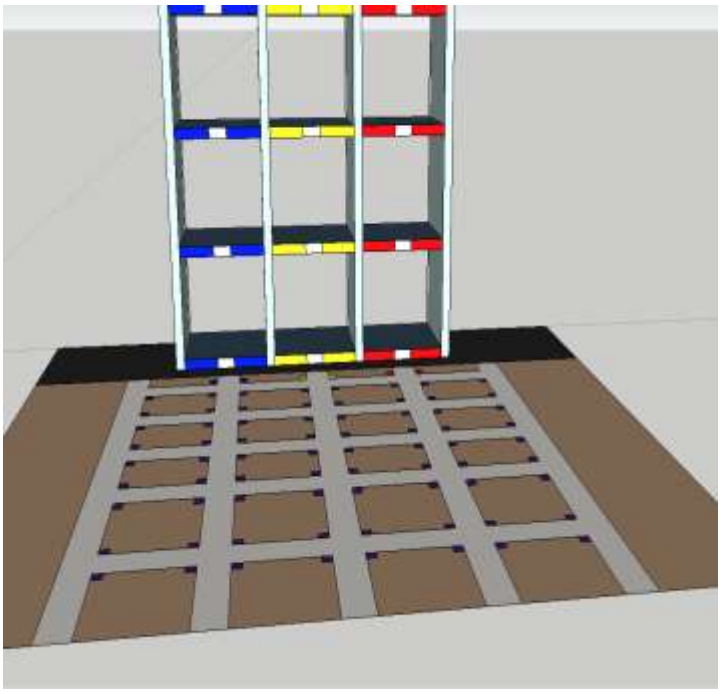

Figure 1. Test Field Design

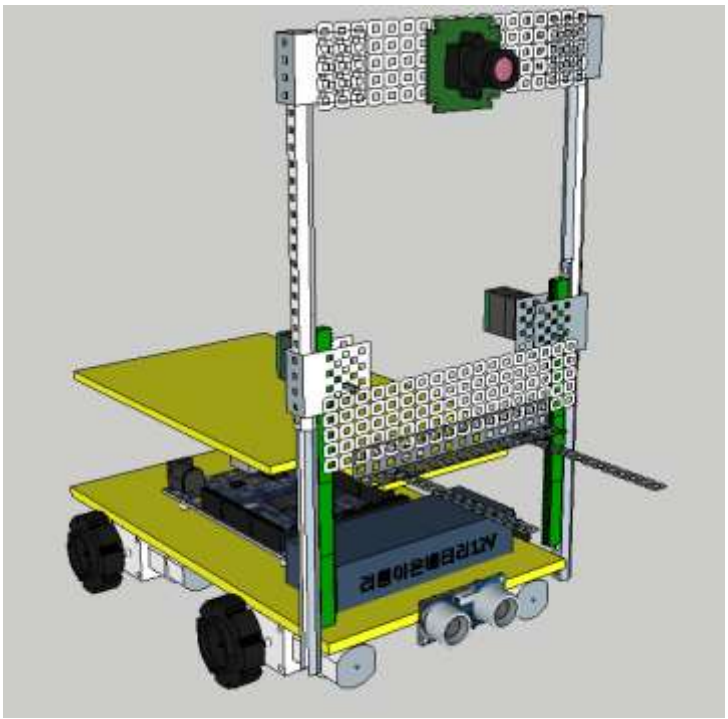

Figure 2. Test System Design

The above image is the model designed exclusively for this experiment.

In the first experiment, we assumed transporting an empty load, and in the second experiment, we assumed one obstacle. The result is as shown in the graph.

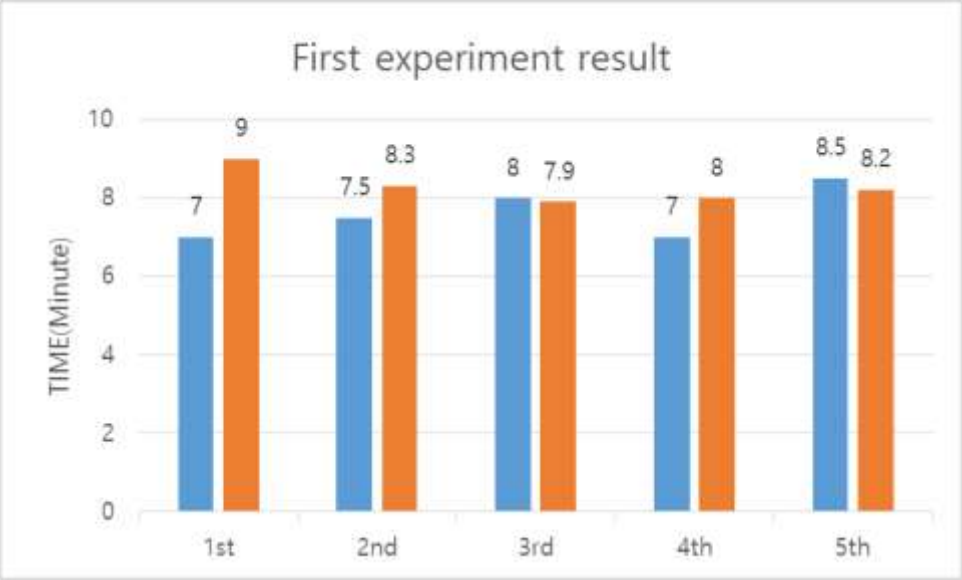

Figure 3. First Experiment Result

From the experiment, it is shown that it takes a considerable amount of time to detect the obstacle and divert but the difference is slight. The next experiment was designed by assuming one obstacle and two obstacles.

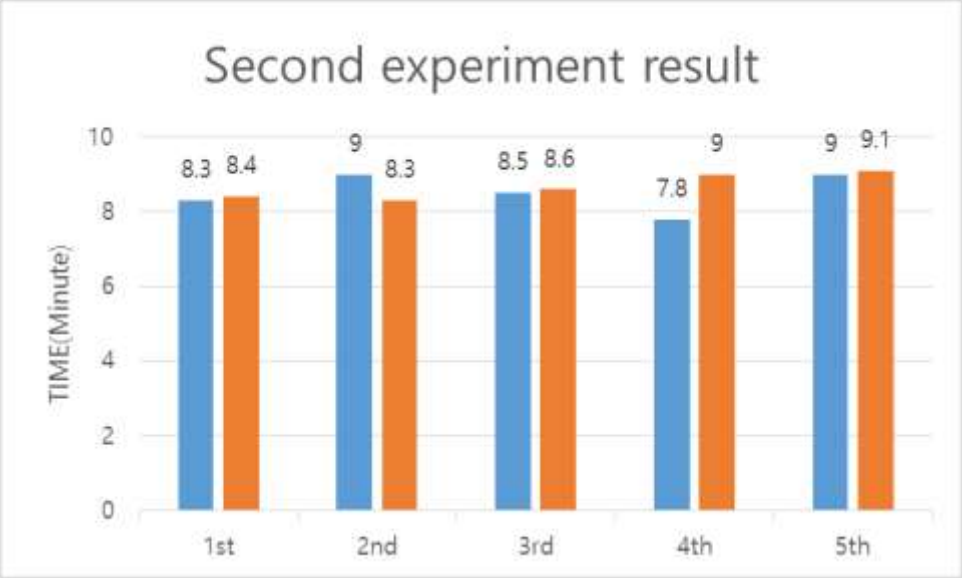

Figure 4. Second Experiment Result

From the above graph, it is shown that there is almost no difference when there are one obstacle and two obstacles. Therefore, it brings us to the conclusion that the designed hypothesis works.

4. Conclusions

In this study, the unmanned logistics management system was implemented based on the simple yet efficient algorithm of detecting traffic lanes using the camera on a forklift using MFC and OpenCV while implementing a C++ server based on Visual Studio. As presented in the result, this proposed algorithm efficiently detected traffic lanes on a straight road and a gentle curve, and showed tenacity over exception processing such as recognition of logistics and processing thereof. Also, by setting up ROI and extracting a primary differentiation edge, the availability of real time processing was confirmed and the need for preventive measure on various error issues from unmanned operations arose.

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