Laser Sensor for Obstacle Detection of AGV

Kyoung-Taik Park*, oung-Tae Shin and Byung-Su Kang
* Nano-Mechanism Lab, Department of Intelligent Precision Machine
Korea Institute of Machinery & Materials
171 Chang-dong, Yoosung-gu, Taejon, Korea
Tel : +82-42-868-7131, E-mail : ktpark@kimm.re.kr

Abstract: AGV is very useful equipment to transfer containers in automated container terminal. AGV must have Obstacle Detection System (ODS) for port automation. ODS needs the function to classify some specified object from background in acquired data. And it must be able to track classified moving objects. Finally, ODS could determine its next action for safe driving whether it should do emergency stop or speed down, or it should change its deriving lane. For these functions, ODS can have many different kinds of algorithm. In this paper, we present one of AGV to be used in automated container terminal.

Keywords: Laser Sensor, Obstacle Detection, Classification, AGV

1. INTRODUCTION

The obstacle detection system is required and useful for AGV to transfer the container form ship to block in yard of the automated container terminal. When the emergent situation is occurred, that is, a man is suddenly appeared in the driving lane of AGV or driving of AGV is obstructed by falling of the freight, there should be the countermeasure to cope with it. The countermeasure is prepared to minimize it because it effects the entire process when one of the processes is stopped in the automated container terminal.

In this research, by using laser scan with measuring range 50 m, the existence of obstacle in driving lane is previously detected to prevent the collision. The algorithm to cluster by comparing the consequent points is used to reduce the processing time to recognize and classify the obstacles. This is to reduce the processing time because of slow data communication in hardware. Therefore, it needs to recognize and classify the obstacle by improving the communication speed. In this paper, the method to cluster by individually comparing all objects and the algorithm to have the high performance of classification are presented.

Fig. 1 Laser Sensor on AGV

2. O STACLE DETECTION S STEM

2.1 System Configuration

The most important problem of ODS to be attached on AGV is the reliability of detecting function. In current port, most cargo handling equipment is drived by operator. In the case of the purpose of unmannizing these handling equipment, they could be derived under the working environment of manually operated equipment. But, realistically, the automated port requires much better arranged working environment than the conventional port. The detecting sensors should be selected by considering the condition of all-weather working under those environments.

Fig. 2 shows the configuration of DSP board to send data of laser scan to PC in order to process and make decision. ODS used the microprocessor (TMS320C32) for processing the acquired data and the serial communication, RS422, for receiving data from laser scanner. The controller of ODS is consisted of the functions to receive data from laser scanner and to send the result of data processing to the main controller of AGV. In order to minimize the processing time to acquire and analyze data, the serial communication, RS422, is used for the high speed communication in hardware.

The sending time of data is reduced by changing the conventional speed, 38.4 kbps, to the maximum speed, 500 kbps. In order to obtain the information of the position and driving direction of the obstacle, the processing time of data should be minimized. In case of the communication speed, 500 kbps, to be supported by laser scanner, the total processing time such as

detecting, processing and sending is 60 ms.

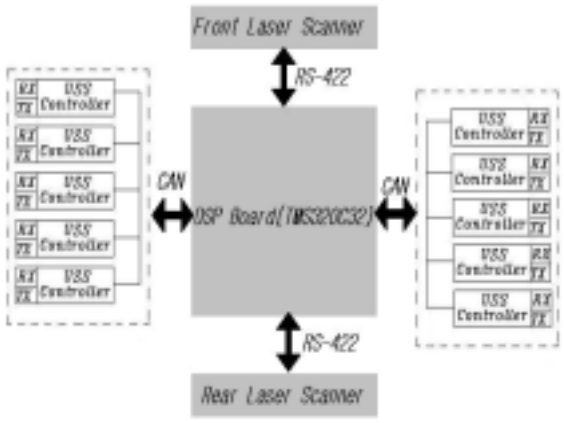

Fig. 2 Configuration of data processing DSP board

If considering the processing time in DSP board, it searches 10 times per second and analyzes the position and deriving direction of the obstacle. In order to add the tracking function, the reduction of sending time of data is very important.

2.2 Recognition and Classification of Obstacle

The case of using the consequent comparison algorithm for the acquired data, the processing time is short but the problem to detect one identical object as more than two separated object is occurred. Therefore, the monitoring area is classified into three categories in order to reduce the processing time of data without using the consequent comparison algorithm. The accuracy of the obstacle detection method is improved by using the individual comparison algorithm of data to be appeared in monitoring area. The reason to set the monitoring area is to prevent the increasing of the processing time of data to be increased by the individual comparison. The purpose of high speed is accomplished by reducing the processing time and excluding the amount of data to be not related with the collision of AGV.

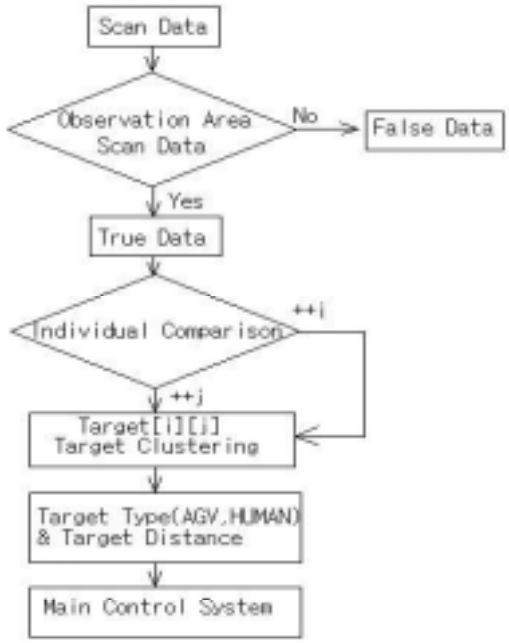

Fig. 3 Clustering algorithm

1) Classification of Obstacle

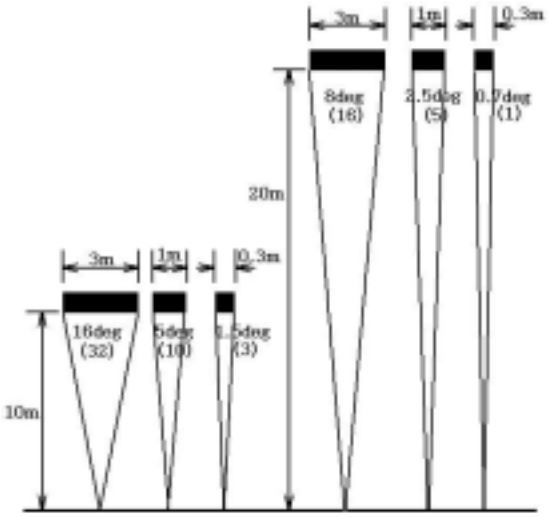

Fig. 4 Number of scanning points

Fig 3 shows the number of laser scanning points to be detected the identical object as changing the distance. Though there are many obstacles in yard, the obstacle is classified in this study by considering only human and AGV. Therefore, the human and AGV are distinguished by the size of width of the acquired obstacle. The coordinates (X_{min},Y_1), (X_{max},Y_2), (X_1,Y_{min}), and (X_2,Y_{max}) are obtained in the obstacle to be classified by the individual comparison algorithm.

Here, the width of the difference between the maximum and minimum values of the *X* coordinate is compared with the width of the difference between the maximum and minimum values of the *Y* coordinate. And then the largest value is referred to the width of the obstacle. The kind of the obstacle such as human and AGV is classified by the size of the width and the data of the result is sent to the main controller.

2) Definition of Obstacle with Distance between Points of Object

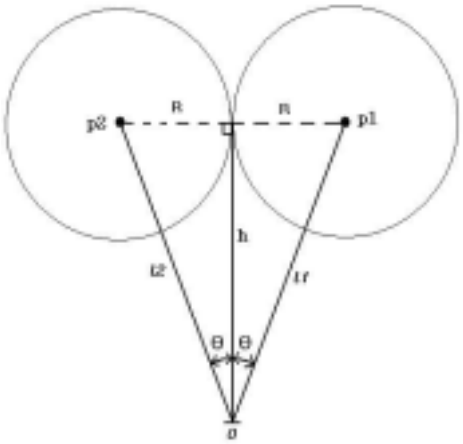

Fig. 5 Distance between targets

The value of the error according to the change of the distance should be determined. But the effect of perspective is not considered. The circles of the same radius R are drawn at point p_1 and point p_2 in Fig 4. Here, the distance from the center of the laser scanner to point p_1 is l_1 and the distance from the center of the laser scanner to point p_2 is l_2. The angle between line op_1 and line op_2 is 2θ (θ = 0.25) when the points, p_1, p_2, are the consequent points. In order to obtain the horizontal minimum distance between point p_1 and point p_2, the scanning distance, l_1, l_2, between the points o and p_1, points o and p_2 are assumed as $l_1 = l_2$.

$$R = l_1 \sin\theta \tag{1}$$

The distance, $2R$, between the point p_1 and p_2 is obtained by Eq (1). The distance, $2R$, is the horizontal minimum distance between the point p_1 and p_2. The angle, 2θ, between line op_1 and line op_2 is constant (θ = 0.25). When the horizontal minimum distance is referred to as the referential value of the error, the horizontal plan is detected but the vertical plan is not detected in object recognition. Therefore, in order to increase the rate of recognition to the vertically sloped plan, the reference value of the error is increased in 2~3 times and obtained by experiments. In this research, the purpose of using of laser scanner is not to draw the map of the reference shape but to recognize the kind of object and to determine the position of it. This process does not have the difficulty that the profile of the shape of object is precisely detected in the map of the reference shape.

3. EXPERIMENTS OF O JECT DETECTION AND CLASSIFICATION

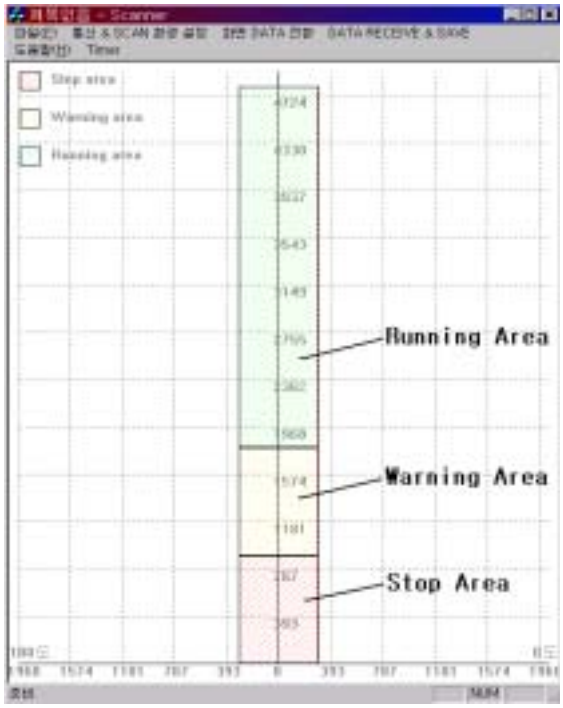

Fig. 6 Scan data Debug Program

Fig 5 shows the example of the debugging program to analyze and acquire data in DSP board.
In practical DSP, this program is not used but the same algorithm is used. Though, in this algorithm, three kinds of monitoring area are used, their number and size could be changed with increasing of the speed of AGV. They are determined by experiment and simulation. The stop area is that AGV should be stopped and then send the emergency message to supervisor if any obstacle is detected in this area. The warning area is that AGV should decrease its own speed and send the warning message of collision to supervisor and then follow the command of supervisor if some obstacle is detected in this area. The running

area is that AGV could drive in safety even if any obstacle is detected in this area.

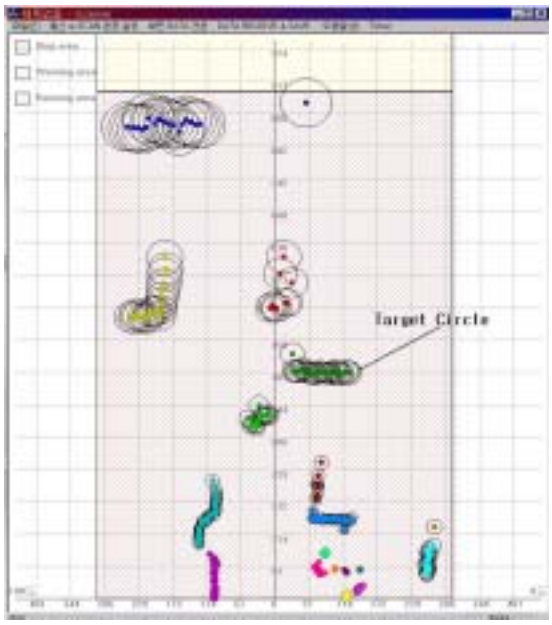

Fig. 7 Scan data & clustering

Fig 6 shows the scanned data to be clustered and analyzed in PC. Here, it shows the different size of the target circle according as the distance changes.
It is the reason that they have the different distance between the points though they are located on the scanning line to have the same rotating angle from the center of laser scanner.

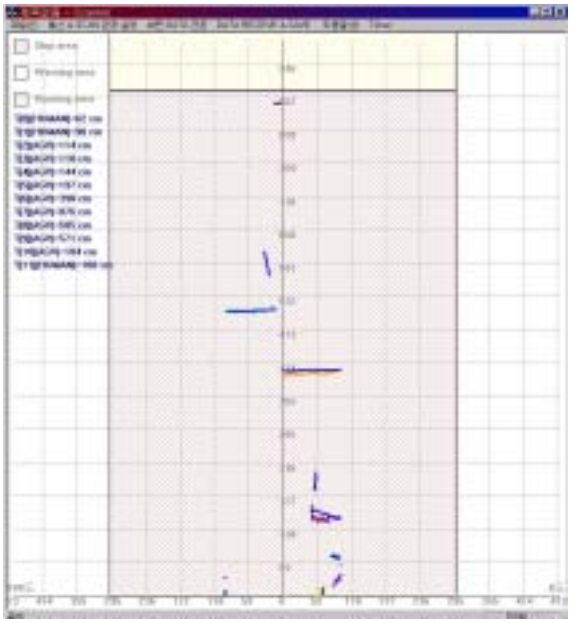

Fig. 8 Clustering in DSP board

Fig 7 shows the objects to be analyzed and classified in DSP board. The kinds of the obstacle such as human and AGV, to be classified by computing the width of each object, are shown in Fig 7. The information such as kinds, position and deriving direction of this obstacle is sent to the main controller. The laser scanners were attached at the front and rear side of AGV and then the functions of AGV were tested in automated container terminal.

Fig. 8 AGV in automated container terminal

Fig. 9 AGV in automated container terminal

4. CONCLUSION

In this research, by using the consequent comparison algorithm and individual comparison algorithm, the results of the experiments are the followings.

1. The consequent comparison algorithm shows the good result of the processing time but the problem of the separated object image of the same identical object when the monitoring area is not used.
2. The individual comparison algorithm shows the speedy result of the processing time and the clear classification and recognition of the obstacle when the monitoring area and the number of data are restricted.
3. The relatively small obstacles are sometimes detected and sometimes not detected when the obstacles are located in long distance from the laser scanner.
4. The experiments of these algorithms were performed under the practical environments in automated container terminal.

Additionally, the processing time of the classification and detection of the obstacle should be reduced and the driving direction, speed and tracking function should be studied.

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