Pallet Recognition and Driving Method for Pallet- engaging of Unmanned Autonomous Forklift

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Abstract: This paper present error minimization using angular histogram for engaging pallet of forklift AGV(autonomous guided vehicle). Existing pallet recognition methods using LRF(laser range finder) have used various linearization methods for error minimization of LRF. However, to apply forklift AGV which need near real-time control, those methods need large amount of operation. Hence we studied error minimization of LRF using angular histogram to search suited linearization for forklift AGV. For experiment, we attach LRF on forklift AGV that we made ourselves, and recognize pallet. In result, we verified that average recognized angle error of pallet is within 1.2° when pallet is placed on far at 2m, 3m from forklift AGV.

Keywords: forklift, AGV, pallet, engaging, LRF, angular histogram

I. INTRODUCTION

In the modern industrial technology, it is importance to production administration so that AGV is actively developed. As a result, it was made huge profits in the cost and time. Especially, the forklift AGV could be used multipurpose, so it is studying popular [1-3].

First, for development of the forklift AGV, the development of autonomous vehicle needs to recognize location of vehicle accurately. Therefore, for localization of vehicle, SLAM(simultaneous localization and mapping), GPS, Laser Navigation System are studying actively.

The forklift needs to engage a pallet through the accurate pallet recognition for automation of the loading and unloading. Therefore, we must know the accurate angle and position for development of forklift. At this time, the forklift AGV need to recognize the accurate angle as well as position for put safely in the hole of pallet. Existing methods for pallet recognition are mainly using stereo vision camera[4,5]. However, the accuracy of methods using camera changes by brightness, the position of camera or environmental condition. So, we think that it's not suitable for the forklift AGV. Therefore, this paper present pallet recognition using LRF(laser range finder) that is less influenced of environmental condition.

This paper is divided into four sections. Section 2 proposes the methods of pallet recognition and section 3 introduces some experimental results for proving proposed methods. Finally, section 4 is conclusions and our future research.

II. PALLET RECOGNITION

We can know position and height of a pallet when a pallet is placed on the rack in work space. But, position and angle of a pallet are changed during repeatedly works. If the forklift AGV recognizes only position of a pallet without angle, it causes any problem. Therefore, the accurate pallet recognition is necessary to solve this problem.

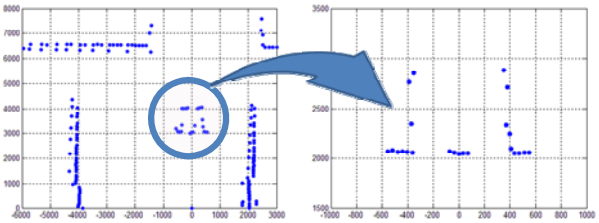
In this paper, we used LRF(URG-04lx) for a pallet recognition. URG-04lx scans every 0.36° between 0° and 240° range and can measure maximum 4 meters. After we set up LRF at the front of fork as shown in Fig. 1., we studied recognition of a pallet.

Fig.1. LRF is set up at forklift AGV

Because shape of the pallet is rectangle, the forklift AGV can recognize the position and angle of a pallet by detecting at the front line of a pallet. Results of LRF scanning a pallet are shown in Fig.2. We are possible to extract region of pallet because of knowing location of the rack.

In the result of LRF scanning, scan data is included noises as shown in Fig.2-(b). So, we needed to reduce noise. In this paper, we proposed angular histogram method for reducing noise. Angular histogram calculate angle of between two points about all points and count every 10°. And then, the forklift AGV recognizes a pallet using both end points of maximal frequency that result of angular histogram.

step 1. Scanning using LRF
step 2. Sampling range of pallet
step 3. Reducing noise using angular histogram
step 4. Detecting at the front line of pallet
step 5. Calculating range of pallet using both end points



(a) Result of scanning (b) Sampled pallet

Fig.2. Result of LRF scanning

III. EXPERIMENTS

1. Experimental environment

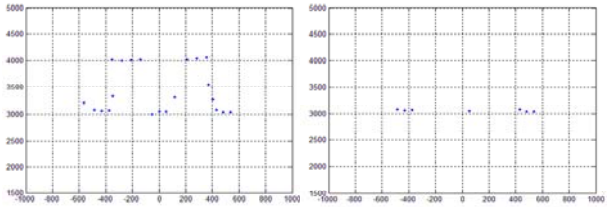
We tested the pallet recognition using the actual forklift AGV for verifying performance. Present position of the forklift AGV were possible to calculate online by localization system. We set up LRF between forks as mentioned in section 2. For engaging pallets, we assumed that forklift AGV has at target point as far 2m from a pallet. This distance(2m) is considered a fork size and the minimum curve radius. If angle of a pallet is between -10° and 10° based the forklift AGV, it is able to insert forks in a pallet by forward driving. In the other case, forklift AGV need to drive back and drive forward to engage pallet. We tested pallet recognition about 0°, 5° and 10° when a pallet is placed on far at 2m and 3m.

2. Experimental Result

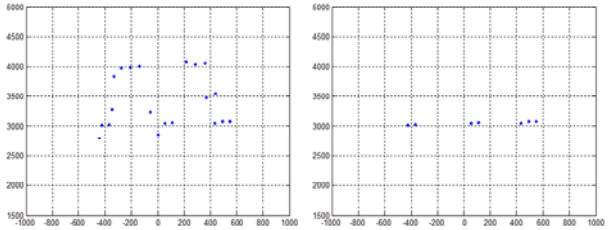
The experiment of pallet recognition is repeated 20 times, and average angle of recognized pallet is shown in Table 1. We could show that recognized angle at 2m is more precise than at 3m. The reason is that LRF is more precise as close. The best results at 3m are shown in Fig.3 and recognized angles of pallet are -0.75°, 4.39° and 8.97°. Similarly, results at 2m are shown in Fig.4 and recognized angles of pallet are 0.41°, 4.98° and 9.69°. Because experimental result is that the average error angle is calculated within 1.2°, this error doesn't influence pallet engaging and doesn't occur any problem. We confirmed that the proposed method effectively reduced noises of LRF and is possible to apply to the forklift AGV for pallet recognition based on experimental result.

Table 1. Experimental result of pallet recognition

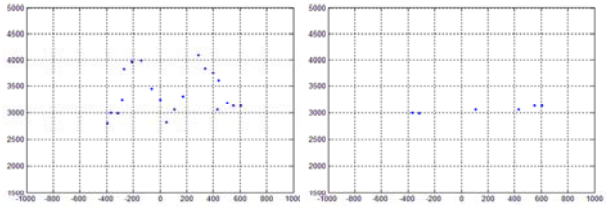
	3m			2m		
	0°	5°	10°	0°	5°	10°
avg.	-1.22	3.73	8.32	-0.98	4.45	8.97
RMSE	1.22	1.27	1.68	0.98	0.55	1.03



(a) 3m, 0°

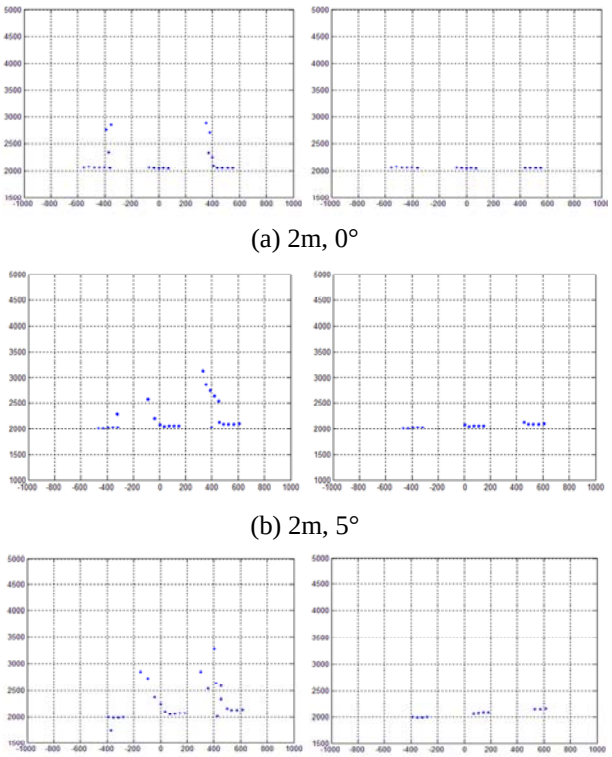


(b) 3m, 5°



(c) 3m, 10°

Fig.3. Pallet recognition result (far 3m from LRF)



(a) 2m, 0°

(b) 2m, 5°

(c) 2m, 10°

Fig.4. Pallet recognition result (far 2m from LRF)

IV. CONCLUSION

This paper proposed pallet recognition and noise reduction for engaging a pallet. We used angular histogram to reduce noise of LRF data and tested proposed method by installing LRF at the actual forklift AGV. Experiment was performed repeatedly 20 times about 0°, 5° and 10° when a pallet is placed on fat at 2m, 3m. The average error of angle is calculated -1.22°, 3.73°, 8.32° at 3m, and it is calculated -0.98°, 4.45°, 8.97° at 2m. This error rates doesn't affect for engaging a pallet. Therefore, we verified the proposed pallet recognition has enough accuracy and is applicable forklift AGV.

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