Feature Extraction Method using Laser Range Finder for SLAM

Taerim Kim, Sungyoung Jung, Jungmin Kim, and Sungshin Kim

School of Electrical Engineering, Pusan National University,
Jangjeon-dong, Geumjeong-gu, Busan, 609-735, Republic of Korea
(Tel : 82-51-510-2367; Fax : 82-51-513-0212)
(Email : {rimkt, pleiades0223, kjm16, sskim}@pusan.ac.kr)

Abstract: In this paper, we propose the feature extraction method from laser range finder data using angle histogram algorithm. Most people commonly know that laser range finder has relatively accurate performance. But noises were existed in experimental result that a few points appeared empty space. We proposed noise reduction method using angle histogram algorithm that accumulated repeatedly counted points in each angle. Laser range finder data with reduced noise is used for the feature extraction method. We find feature point using that one line lies cross at right angles to another line. And we tested simulation of SLAM using the feature extraction.
+

Keywords: Feature Extraction, SLAM, Laser Range Finder, Mobile robot, Angle histogram, EKF

I. INTRODUCTION

Recently, there is popular research field of robot such as application for army, home and education, etc. Among various kinds of robots, mobile robot is particularly actively researched. For autonomous movement of robot, it is important to localization and environmental recognition (Related research is called simultaneous localization and mapping). It can know using odometry from various sensors (sonar, infrared, laser, vision. etc.). One of sensors is laser range finder that it becomes popular in mobile robot[1]. Because it provides dense and more accurate range measurements, it has good range distance and resolution. For example, laser range finder has been used in localization, map building, collision avoidance. We also use laser range finder for feature extraction[2, 3]. We can know how to accurately match sensed data against information in a priori map through feature extraction.

This paper proposed feature extraction method for SLAM. First, we tested to use laser range finder and propose laser range finder noise reduction method using angle histogram[4]. And we tested feature extraction from laser range finder data by SLAM simulation.

II. LASER RANGE FINDER NOISE

We use laser range finder (LMS200) for SLAM for the reason that laser range finder is relatively more accurate than others. LMS200 can measure every 1 degree and maximum distance is 8m. But experimental result is that laser range finder data included irregular white noise as shown in Fig. 1. Therefore, laser range finder data is used selective data in 4m for precise feature point and need to precede noise reduction.

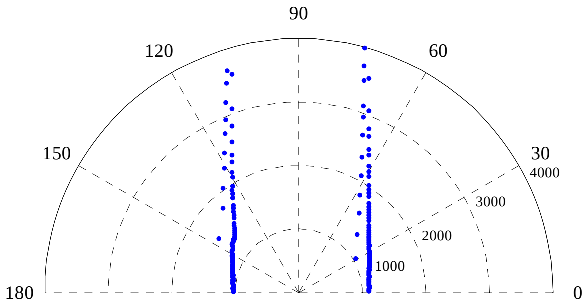


Fig.1. Measurement laser range finder

III. NOISE REDUCTION USING ANGLE HISTOGRAM

We propose angle histogram for irregular noise reduction of laser range finder. In this paper, Because our object is indoors environment SLAM, we assumed according to :

1. Noise of laser range finder data is irregular and unpredictable white noise.
2. General indoors environment consists of a hallway, wall, corner, door, etc. and can be described straight lines.
3. Angle of continuous data has regular in indoors environment which consists of straight lines.

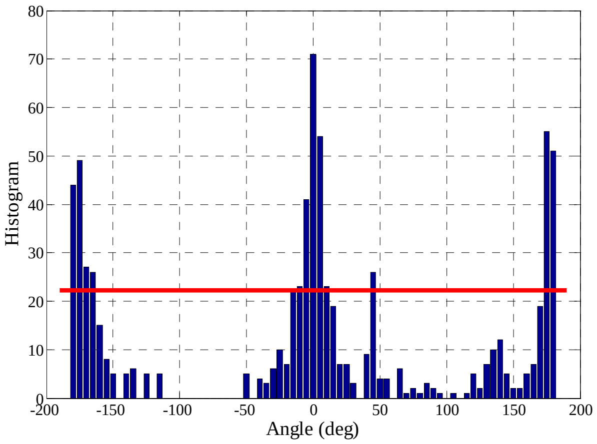
If we use these assumptions, then noise reduction is possible to use angle histogram. First, for angle histogram, we convert cylindrical coordinates to rectangular coordinates because of laser range finder data have cylindrical coordinates.

$$x(i) = x_k + r_x \times (\theta_k + i - 90)$$
$$y(i) = y_k + r_y \times (\theta_k + i - 90) \quad (i = 0, 1, 2, \cdots, 180) \tag{1}$$

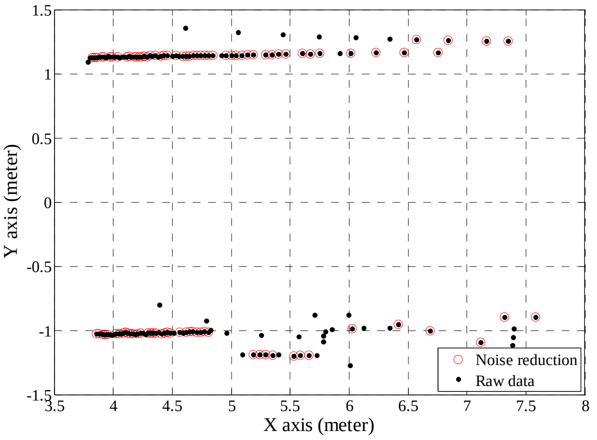
where (x_k, y_k, θ_k) denote a position of robot. And every angle of continuous points is calculated in (2).

$$T(i) = \text{atan}(\frac{x(i) - x(i-1)}{y(i) - y(i-1)}) \quad (i = 0, 1, 2, \cdots, 180) \tag{2}$$

We made angle histogram using calculated angles and extracted that magnitude is over 15 percent. Therefore, we can reduce white noise and remained data is possible to describe straight line. We confirmed noise reduction using angle histogram as shown in Fig. 2.



(a) Angle histogram



(b) Apply angle histogram to laser range finder data

Fig.2. Noise reduction using angle histogram

IV. FEATURE EXTRACTION METHOD

This paper is limited to 2D indoors environment and target performing SLAM. We used only laser range finder so that just obtained little information. So we selected clearly distinguishable feature points such as corners of hallway, wall, and door. In advance, we assumed according to :

1. A hallway is generally made straight lines and has irregularly door, stair, locker, etc.
2. The corner is generally made a rectangular line in a hallway.
3. Distance of between the walls is minimum 1.5m.
4. Ground is flat so that measurement error of laser range finder is none.

When feature extract under assumption, we can think two direction of mobile robot such as forward and backward. First, forward searching is that mobile robot look between the walls of corner. Second, backward searching is that mobile robot look one side of a wall and don't look opposite side of a wall.

1. Forward searching

Forward searching is that we select right and left points of regular distance from based point. Using points make straight line and we can judge feature by whether two lines is rectangular.

Right and left points is selected far 300, 600, 900, 1200mm from based point and L_{pt}, R_{pt} is defined (3) , (4). We need to calculate angle from based point for judgment whether feature using selected points like (5), and (6). And we tested proposed forward searching as shown in Fig. 3.

$$L_{pt} = \left[\begin{bmatrix} x_{lpt} \\ y_{lpt} \end{bmatrix}_{300} \begin{bmatrix} x_{lpt} \\ y_{lpt} \end{bmatrix}_{600} \begin{bmatrix} x_{lpt} \\ y_{lpt} \end{bmatrix}_{900} \begin{bmatrix} x_{lpt} \\ y_{lpt} \end{bmatrix}_{1200} \right] \tag{3}$$

$$R_{pt} = \left[\begin{bmatrix} x_{rpt} \\ y_{rpt} \end{bmatrix}_{300} \begin{bmatrix} x_{rpt} \\ y_{rpt} \end{bmatrix}_{600} \begin{bmatrix} x_{rpt} \\ y_{rpt} \end{bmatrix}_{900} \begin{bmatrix} x_{rpt} \\ y_{rpt} \end{bmatrix}_{1200} \right] \tag{4}$$

$$Slope_L = \begin{bmatrix} \text{atan}(y_{lpt} - y_{idx}, x_{lpt} - x_{idx}) |_{300} \\ \text{atan}(y_{lpt} - y_{idx}, x_{lpt} - x_{idx}) |_{600} \\ \text{atan}(y_{lpt} - y_{idx}, x_{lpt} - x_{idx}) |_{900} \\ \text{atan}(y_{lpt} - y_{idx}, x_{lpt} - x_{idx}) |_{1200} \end{bmatrix}^T \tag{5}$$

$$Slope_R = \begin{bmatrix} \text{atan}(y_{rpt} - y_{idx}, x_{rpt} - x_{idx}) |_{300} \\ \text{atan}(y_{rpt} - y_{idx}, x_{rpt} - x_{idx}) |_{600} \\ \text{atan}(y_{rpt} - y_{idx}, x_{rpt} - x_{idx}) |_{900} \\ \text{atan}(y_{rpt} - y_{idx}, x_{rpt} - x_{idx}) |_{1200} \end{bmatrix}^T \tag{6}$$

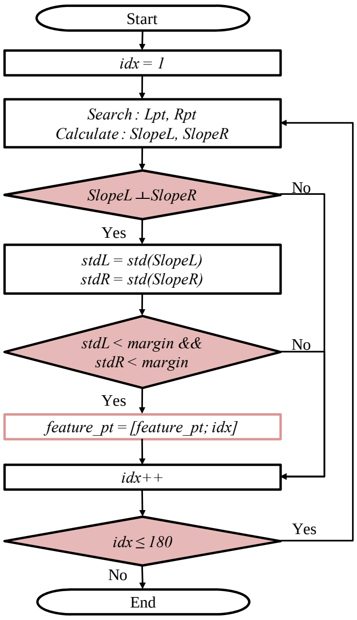


Fig.3. Forward searching algorithm

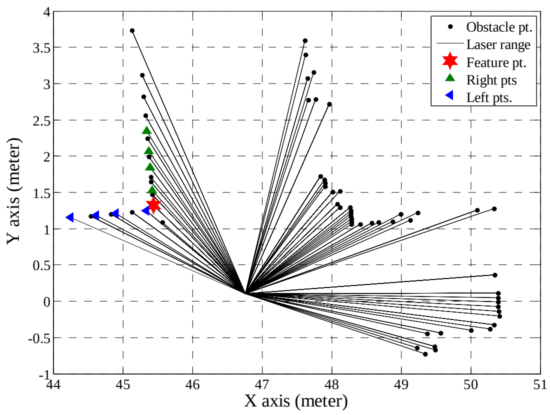


Fig.4. Feature extraction using forward searching

2. Backward searching

We can judge a corner by confirming distance between continuous points because of that mobile robot looks only one side of a wall. Backward searching algorithm is expressed to use flow chart as shown in Fig. 5. Because mobile robot don't look opposite side of a wall, between continuous points could have a far distance over 1.5m. But laser range finder data is used under 4m and over data is defined infinite as mentioned section 1. So, we judge that based point and next point have whether a finite value or infinite value. If two points have a finite value and distance between two points is over 1.5m, then feature is defined near point of two points with robot as shown in Fig.6.(a). In the other case, if two points have infinite value and distance between next point and robot is less than difference between max distance 4m and 1.5m, then feature is defined next point as shown in Fig.6.(b).

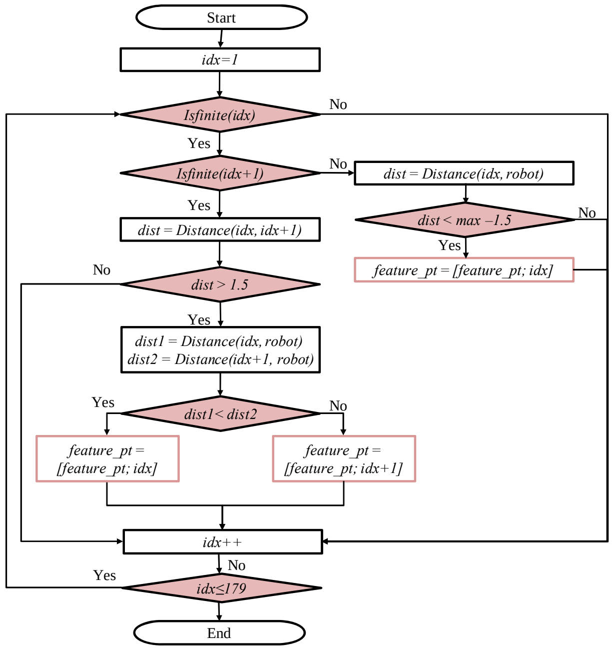
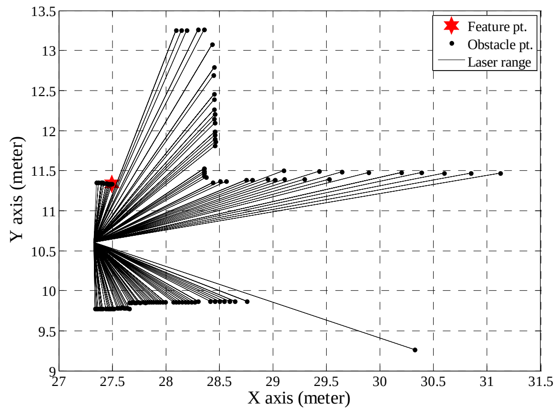
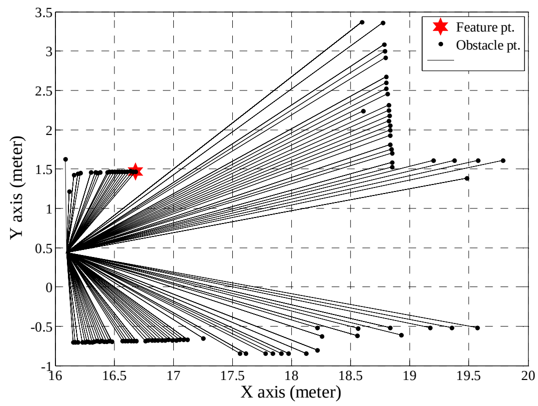


Fig.5. Backward searching algorithm



(a) Feature extraction (finite)



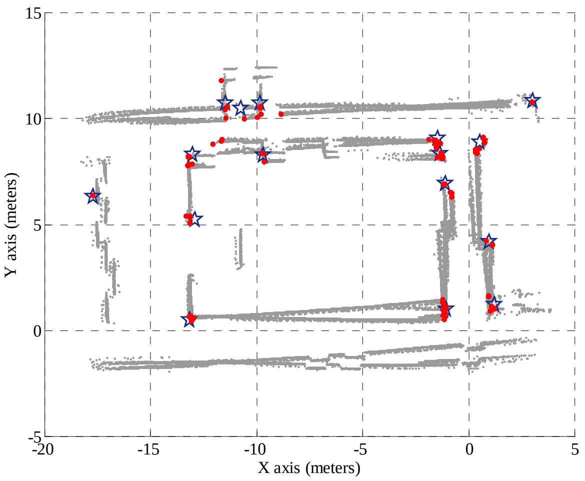
(b) Feature extraction (infinite)

Fig.6. Feature extraction using backward searching

V. SLAM

We tested feature extraction using laser range finder by SLAM simulation. SLAM used extended kalman filter for estimation of posterior distribution of feature and robot's position[5]. We used mobile robot in Fig. and simulation result is good performance as shown in Fig.

(a) Mobile robot



(b) EKF-SLAM using feature extraction

Fig.7. Feature extraction using forward searching

VI. CONCLUSION

This paper proposed feature extraction method using laser range finder for SLAM. We tested laser range finder and confirmed that data is included irregular white noise. For noise reduction, we used angle histogram and experimental result is shown reduced noise. And we extracted feature using reduced noise data. We proposed feature extraction method that two ways are forward and backward searching. Because a hallway generally consists of straight lines, feature is defined corners. Using proposed method, SLAM simulation result is confirmed good performance of localization and robust repeatedly many continuous data.

Because proposed method is developed under assumption that SLAM execute indoors environment, then has many assumptions and restrictions. So, there remains to be more studied feature extraction in outdoors environment for SLAM.

Acknowledgment This work was supported (Pusan National University Specialized Environment Navigation/ Localization Robot Technology Research Center) by Ministry of Knowledge Economy under Human Resources Development Program for Convergence Robot Specialists.

REFERENCES

[1] Viet Nguyen, Agostino Martinelli, Nicola Tomatis, Roland Siegwart (2005), A Comparison of Line Extraction Algorithms using 2D Laser Rangefinder for Indoor Mobile Robotics. Intelligent Robots and Systems. 1929-1934

[2] I. Tena Ruiz, Y. Petillot, D. M. Lane, C. Salson (2001), Feature Extraction and Data Association for AUV Concurrent Mapping and Localisation. International Conference on Robotics & Automation. 3:2785-2790

[3] Kai Oliver Arras, Roland Y. Siegwart. (1997) Using histogram correlation to create consistent laser scan maps. Proceedings of SPIE. 3210:42-53

[4] Rofer.T. (2002), Using histogram correlation to create consistent laser scan maps. Intelligent Robots and Systems. 1:625-630

[5] J. Weingarten, R. Siegwart (2005), EKF-based 3D SLAM for Structured Environment Reconstruction. Intelligent Robots and Systems. 3834-3839