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OCCUPANCY GRID MODELING FOR MOBILE ROBOT USING ULTRASONIC RANGE FINDER

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ABSTRACT

To achieve full autonomy in mobile robot, it is essential to sense the environment accurately. Sensor plays a fundamental role in the autonomy process of mobile robot. Ultrasonic range finder is most widely used sensor for this purpose however it produces uncertainty. To reduce uncertainty generated from ultrasonic range finder an appropriate representation of sensory information is required. Occupancy grid modeling is a geometric representation for modeling the sensor reading produced by ultrasonic range finder. Here we use Elfes-Moravec model to represent sensory information.

Index Terms: Occupancy Grid, Ultrasonic Range Finder, Mobile Robot.

I. INTRODUCTION

In order to achieve full autonomy for a mobile robot, it is essential to sense the environment accurately. Sensor plays a fundamental role in the autonomy process of mobile robot. Various types of sensor such as ultrasonic range finder, infrared sensor, laser sensor, vision sensor etc are used for environment mapping [1-8].

Each of the above mentioned sensors has its own drawbacks. The Ultrasonic range finder for instance suffer from wide beam cone, specular reflection, crosstalk etc [4,8]. On the other hand lasers available in market are expensive and transparent to some material. Stereo vision systems are very sensitive to changes in illumination and the algorithms that exist are computationally expensive [8,11]. This generates uncertainty.

To reduce uncertainty generated from Ultrasonic range finder an appropriate representation of sensory information is required. Occupancy grid modeling is a geometric representation for modeling the sensor reading produced by ultrasonic range finder. Here we use Elfes Moravec model to represent sensory information.

II. ULTRASONIC RANGE FINDER

Sonar refers to any system for using sound to measure range. Sonar stands for Sound Navigation and Ranging. Sonar for different applications operate at different frequencies; for example, sonar for underwater vehicles would use a frequency appropriate for traveling through water, while a ground vehicle would use a frequency more suited for air. Ground vehicles commonly use sonar with an ultrasonic frequency just at the edge of human hearing. As a result the terms "sonar" and "ultrasonic" are used interchangeably when discussing extracting range from acoustic energy.

Fig. 1 Ultrasonic Range Finder

III. SENSOR MODEL

Elfes and Moravec [1], the researcher models the sonar beam as two probability density function, f_E and f_O. These function measure the confidence and uncertainty of an empty and occupied region in the cone beam of the sonar respectively. In this model the following is defined:

- r Range measurement.
- $P^O_{i,j}$ Probability of a particular cell being occupied.
- $P^E_{i,j}$ Probability of a particular cell being empty.
- r_{min} Minimum distance.
- ε Mean sonar deviation error.
- ω Width of the cone.
- S_s sonar sensor
- δ_r Distance between S_s to $C_{i,j}$.
- θ Angle between the main axis of sonar beam to the line $S_s C_{i,j}$.

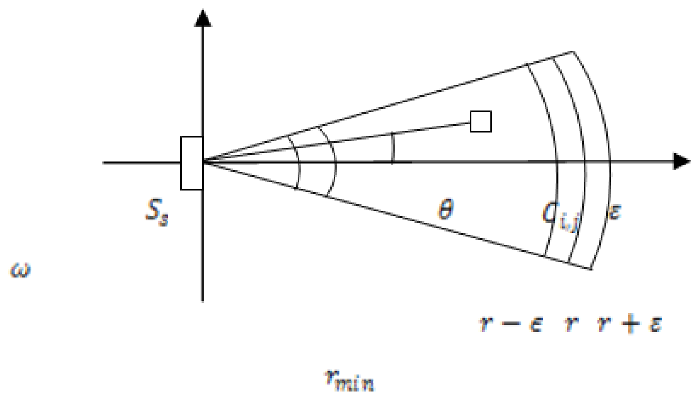

Fig.2 Field of View of the Sonar Sensor

The beam is divided in two regions:

a. The free space area or empty probability region which is the part of the beam between the sensor and the range where the obstacle was detected. This includes cell $C_{i,j}$ inside the sonar beam. Each cell has an empty probability :

$$P^e_{i,j} = E_r(\delta_r).E_a(\theta) \quad (1)$$

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$E_r(\delta_r)$ is the estimation of the free space cell based on the range measurement from the sonar. The closer it is to the sensor the more likely it is to have a high estimation that the cell is empty.

$$E_r(\delta_r) = 1 - \left(\frac{\delta_r - r_{min}}{r - \varepsilon - r_{min}}\right)^2 \qquad (2)$$

$$for \;\; r_{min} \le \delta_r \le r - \epsilon$$

$$E_r(\delta_r) = 0 \qquad otherwise$$

$E_a(\theta)$ is the estimation that the cell is free based on the angle of the cone beam. The closer it is to the main axis and to the sonar the more estimate that it is empty.

$$E_a(\theta) = 1 - \left(\frac{2\theta}{\omega}\right)^2 \qquad for \; \frac{-\omega}{2} \le \theta \le \frac{\omega}{2} \qquad (3)$$

$$E_a(\theta) = 0 \qquad otherwise$$

b. The occupied area or probability occupied region. This is the area where the obstacle was detected. In this region the uncertainty to the exact distance to the obstacle (ε) has to be taken into account. The probability of a cell being inside the occupied region is :-

$$P_{i,j}^{o} = O_r(\delta_r).O_a(\theta) \qquad (4)$$

$O_r(\delta_r)$ is the estimation is based on the range reading . The closer the obstacle is to the sonar the higher the probability that the cell is occupied

$$O_r(\delta_r) = 1 - \left(\frac{\delta_r - r}{\varepsilon}\right)^2 \;\; for \; (r - \varepsilon) \le \delta_r \le (r + \varepsilon) \qquad (5)$$

$$O_r(\delta_r) = 0 \qquad otherwise$$

$O_a(\theta)$ is the estimation is based on the difference of the angle between the obstacle and the beam axis. The closer the obstacle is to the sonar the higher the probability that the cell is occupied.

$$O_a(\theta) = 1 - \left(\frac{2\theta}{\omega}\right)^2 \qquad for \; \frac{-\omega}{2} \le \theta \le \frac{\omega}{2} \qquad (6) \qquad O_a(\theta) = 0 \qquad otherwise$$

IV. SENSOR MODEL RESULT

The sensor reading is modeled using occupancy grid as shown in figure 3. Here it is clear that occupied area is represented as hill, empty area as valley and unknown area as plane surface.

Unknown area is that area which is not covered by sensor. Occupied area is that area, where object may be present. Empty area is that area where robot can move easily. Refer to figure 4, in gray scale representation; it is clearer that object is present in white cells.

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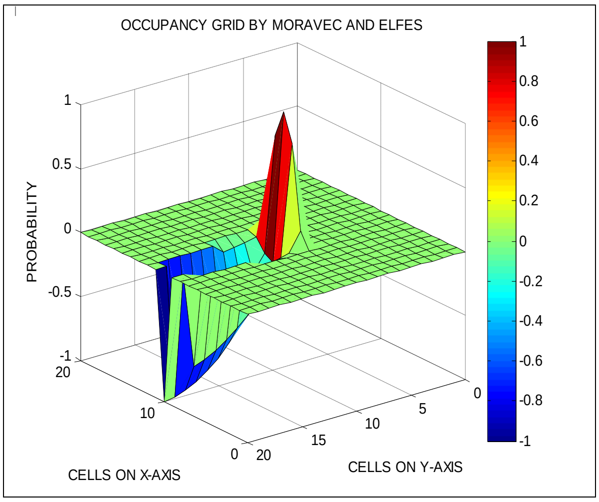

Fig.3 3D View of Occupancy Grid Modeling for Ultrasonic Range Finder

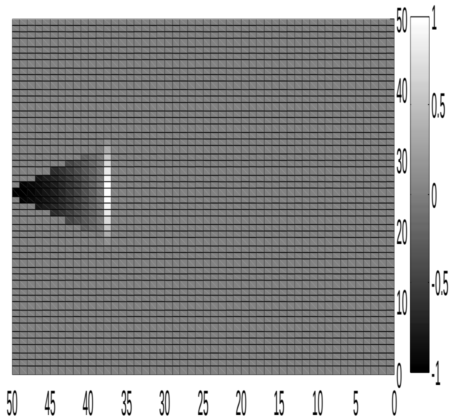

Fig.4. Gray Scale Representation of Occupancy Grid Modeling for Ultrasonic Range Finder

V. CONCLUSION

From result of sensor modeling, it is clear that only sensor reading is not sufficient to identify the object. Hence appropriate sensor modeling is highly needed. As we can see in gray scale representations that object may be present in one cell but due to wide beam cone of ultrasonic sensor, it is represented in more cells. This problem can be minimized by fusing ultrasonic sensory information with laser sensor information.

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REFERENCES

[1] Hans P. Moravec, Alberto Elfes, "High Resolution Maps from Wide Angle Sonar,"Proc. IEEE Int'l Conf. on Robotics and Automation, CS Press, Los Alamitos, Calif, pp. 116-121, March 1985.

[2] H. P. Moravec, "Sensor Fusion in Certainty Grid for Mobile Robots," AI magazine, vol. 9, pp. 61-74, 1988.

[3] A.Elfes. Using occupancy grids for mobile robot perception and navigation. IEEE Computer, 22 (6):46-57, 1989.

[4] Zou Yi, Ho Yeong Khing, Chua Chin Seng, and Zhou Xiao Wei,"Multi-ultrasonic Sensor Fusion for Mobile Robots, Proceedings of the IEEE Intelligent Vehicles Symposium 2000Dearborn (MI),USA , pp.387-391, october 3-5, 2000.

[5] Sebastian Thrun, "Learning Occupancy Grid Maps with Forward Sensor Models," Autonomous Robots ,Vol.15, pp. 111–127, 2003.

[6] Robin R. Murphy, "Dempster–Shafer Theory for Sensor Fusion in Autonomous Mobile Robots", IEEE Transactions on Robotics and Automation, Vol. 14, No. 2, April 1998, pp 197-206.

[7] Robin R. Murphy, "Introduction to AI Robotics", Prentice-Hall of India Private Ltd, 2004.

[8] Sv. Noykov, Ch. Roumenin, "Occupancy Grids Building by Sonar and Mobile Robot", Robotics and Autonomous System, Vol. 55, pp 162-175, 2007.

[9] Md. Abdel Kareem Jaradat, Reza Langari, "Line Map Construction using a Mobile Robot with a Sonar Sensor", Int'l Conf. on Advanced Intelligent Mechatronics, Monterey, California, USA, 24-28 July, 2005.

[10] Alfredo C. Plascencia, "Sensor Fusion for Autonomous Mobile Robot Navigation" A Ph.D Thesis, Automation and Control, Aalborg University, Denmark, August 2007, pp 1-114.

[11] Thierry Bosch ,"Crosstalk Analysis of 1 m to 10 m Laser Phase-Shift Range Finder. IEEE Transaction on Instrument and Measurement, vol.46, No.6, pp.1224-1228, december 1997.

[12] Ian Lane Davis , Anthony Stentz, "Sensor Fusion For Autonomous Outdoor Navigation Using Neural Networks," IEEE International Conference, pp. 338-343, 1995.

[13] Ilyas Eker , Yunis Torun , "Fuzzy Logic Control to be Conventional Method," Energy Conversion and Management ,Vol.47, pp. 377–394, 2006.

[14] J. Carlson, R.R. Murphy, S. Christopher, J. I lkka Autio, Tapio Elomaa, "Flexible view recognition for indoor navigation based on Gabor filters and support vector machines," Pattern Recognition, Vol. 36, Issue 12, pp. 2769-277, 9 December 2003.

[15] J.A. Malpica, M.C. Alonso, M.A. Sanz , "Dempster–Shafer Theory in Geographic Information Systems: A survey," Expert Systems with Applications ,Vol.32, pp. 47–55, 2007.

[16] J.Gonzalez, J.L. Balnco, C. A. Fernandez Modrigal, F.A. Moreno, J.L. Martinez, "Mobile Robot localization based on Ultra Wide Band Ranging," Robotics and automation system, 2008 article in press.

[17] Jan C. Becker , "Fusion of Heterogeneous Sensors for the Guidance of an Autonomous Vehicle", ISIF 2000, pp 11-18, 2000.

[18] Jennifer Carlson, Robin R. Murphy, Svetlana Christopher, Jennifer Casper, "Conflict Metric as a Measure of Sensing Quality," Proceedings of IEEE International Conference on Robotics and Automation Barcelona, Spain, pp. 2032-203, 9 April 2005.