I J C T A, 10(8), 2017, pp. 725-731 ISSN: 0974-5572

Embedded Linux Based Negative Obstacle Detection for Safe Navigation of Robot using Lidar Sensor

Kalyani Bhongale* and Sonal Gore**

ABSTRACT

Obstacle avoidance is the task of satisfying some control objective subject to non-intersection or non collision position constraints. Detection of obstacles and avoidance is essential for the safe navigation for robots in the environment.In order to operate efficient obstacle avoidance technique, many successful robot systems depend on the sensing capabilities and obstacle detection modules of the robot to obtain collision-free motion. This paper proposes an efficient obstacle detection and obstacle avoidance algorithm based on 2-D lidar. Lidar (Light Detection and Ranging) has the advantages of high precision, large detection range, and fast sweep frequency. It is widely used in the obstacle detection field of robotics.

Keywords: Omni directional, Robot, GMM based

1. INTRODUCTION

Safe Robot Navigation is the most currently reviewed research in the field of the Robotics, In many of the applications such as military areas for diffusing of the defections of the things which cannot be done by the human beings, For the safe robot vision sensor are the effective equipments which can be used for the obstacle detection of the safe monitoring system which is based on the features of the images. Image processing play a strong role in the field of robotics, Autonomous robots are the robots which work and act independently without any dependency. The work is based on the images analysis and the omnidirecional camera i.e panoramic images which gives the images of the 360 degree which is very much beneficial for robot navigation as the robot is able to detect the obstacles if present on the backside of the robot. Robotics vision is the main current scheme in the field of Robotics, as the omnidirectional image or the panoramic images are been used for realizing autonomous safe navigation of robot in the environment.

Auted forttautothe of negative sloes. here the presentation of the data taken from the lidar sensor has been used for the efficient searching and detection of obstacles. negative obstacle detection methods and software that have been. developed for this research are designed for an unmanned ground vehicle using a lidar the work can be used in other applications like public vehicles and the vision of technology in computer and other systems.

2. LITERATURE SURVEY

Obstacle avoidance ability is the significant embodiment of the robot, and the basic guarantee of the robots to perform various tasks. Obstacle avoidance technologies are divided into two kinds, one is based on the global map and another is based on sensors respectively. The work mainly aims at the local obstacle avoidance method based on sensors. The study of obstacle detection and obstacle avoidance are two inseparable parts in the research of obstacle avoidance ability.[2]

* Department of Computer Engineering Pimpri Chinchwad College of Engineering Pune-44, *Email: kalyanibhongale24@gmail.com*
** Professor of Computer Engineering Pimpri Chinchwad College of Engineering Pune-44, *Email: sonalgore@gmail.com*

The most commonly used local obstacle avoidance method is the artificial potential field method (APF) and visible graph method they all have the advantages of a simple mathematical model and good real-time performance. The theory of artificial potential field (APF) was propose for the influence of the target on the robot as virtual attractive force, and the influence of obstacles on the robot as virtual repulsive force, the direction of the resultant force is also the direction of the next movement of the robot The traditional artificial potential field method has some problems, such as local optimal solution, and target inaccessible when robot is near to the target.[3]

Vector field Histogram is a three stage method of obstacle avoidance. In first stage 2D histogram is generated around the robot that represents the obstacles.2D histogram is updated with new coming percepts from sensors. In the second step, this 2D histogram is converted to 1D histogram and then polar histogram.[3]

Bug algorithm when robot detects an obstacle it start moving around it until reaches to starting point from where it has started. During its movement around an obstacle, it calculates a leaving point with minimum distance to destination and generates new path from calculated leaving point to destination. After its one complete circle, it restarts its motion around obstacles until reaches to leaving point and starts moving on new generated path to reach the destination [3].

Follow the Gap method is based on the construction of a gap array around the vehicle and calculation of the best heading angle for heading the robot into the center of the maximum gap around, while simultaneously considering the goal point. These two aims are considered simultaneously by using a fusing function. FGM can reach the goal point while avoiding obstacles but in APF method, robot gets stuck because of the local minimum where all vectors from the obstacles and goal point zero each other. FGM selects the first calculated gap value if there are equal maximum gap. This provides FGM to move if at least one gap exists.[4]

Obstacle are the particles that oppose the robot to reach its destination in the shortest path or the objects that are surrounded by the robot in case the robot is random towards the destination. There are several methods to detect the obstacles based on the sensor which is used. Path planning for autonomous vehicles requires that the map of all potential obstacles be produced in real time using available sensor data. The sensor can be used to avoid collision of robot with any obstacles that is present in the path of robot.[2]

3. APPROACH

Negative obstacles are difficult to detect, especially at long ranges, but methods used have included searching for negative slopes that are too steep or gaps in data that exceed a distance threshold followed by a drop in elevation or a steep.

3.1. Selection of the sensor

The Selection of the sensor is to be done for the negative obstacles detection and software which has to be used in the method is taken from the lidar sensor. an efficient obstacle detection and obstacle avoidance algorithm based on 2-D Lidar. A method is proposed to get the information of obstacles by filtering and clustering the data required for the detection of the off road negative obstacles.

Lidar systems use rotating hexagonal mirrors which split the laser beam into 6 beams. The upper 3 layers are used to detect the forward objects such as vehicles and roadside objects. The data detected by LIDAR are clustered to several segments .Data clustering here is done based on characteristics of each segment based on object model, which distinguish different objects such as vehicles, signboards etc. These characteristics are the dimensions of the object.

LMS 111 is the lidar sensor which is been used e here for acquisition of the reading and data for the obstacle detection. it has a FOV(Field of View) within 270° and accuracy of 0.5, 541 distance data and the corresponding 541 intensity data can be acquired. Distance data and intensity data are acquired for each

Figure 1: LMS 111 2D Lidar Sensor

range from 270° to 0.5°. Distance data and intensity data are acquired in the form of a character string and each form is hexadecimal number.

3.2. Different Negative Obstacles

Negative obstacles are the obstacles which are the off road obstacles found under the ground which has to be detected by robots taking the reading of the sensor by the local obstacle method by using sensor.Negative obstacles are ditches or terrain with a steep negative slope that if traversed would be a hazard to the vehicle. Negative obstacles can be just as hazardous to unmanned vehicles as obstacles above ground because they could cause roll-over, tip-over, or high-centering. ditches that are larger than the width of the diameter of the wheel are enough to cause damage to a vehicle. Obstacles of greater widths may be crossed by vehicles at high enough speeds, but we will not be attempting to provide navigation.

3.2.1. Range Detection and Distance for stopping Measurement

There are some of the obstacles which are very difficult to detect from the close distance and it is impossible for them to detect them for long distance. For solving the difficulty of detecting the obstacles the range R has to be illustrated in it.

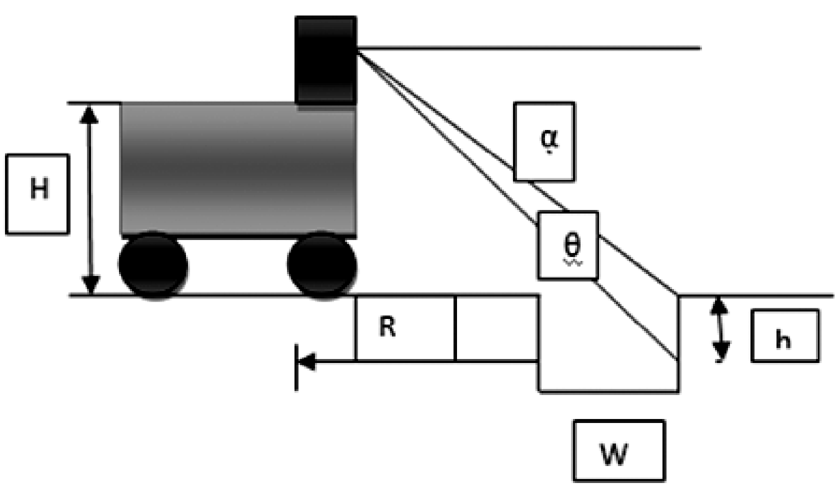

Figure 2: Negative obstacle detected by Geometry

The width of the obstacle is w, H is the height of the sensor from the ground, h is the depth of the obstacle seen by the sensor, and R is the range from the sensor to the obstacle. The equation to solve for is:

$$\omega \approx \frac{H\psi}{R(R+\psi)}$$

The angle ω, decreases significantly as the range increase (~1/R2), which makes negative obstacles so difficult to detect as range increases.

Stopping distance for a vehicle can be determined using

$$R = \frac{v}{2\mu g} + vTr' + \mathrm{B}$$

where is the coefficient of static friction between ground and wheels with a common value of 0:65 for off-road driving, g is gravitational acceleration with a value of 9:8m = s2, Tr is the total reaction time with a common value of 0:25s, and B is a buffer distance used for safety with a value of 2m . The velocity value becomes the dominant term at v > 3:2m/s: for a velocity of 24 kph, the distance needed to stop is 7.2m; for a velocity of 48kph, the distance needed to stop is 19.4m.

3.2.2. NODR Classification Approach

As there is huge difficulty in the detection of the negative obstacles, the negative obstacle detection classification detector is used to get the data, detecting the potential negative and labelling the potential negative obstacle as they come more close to the range and the data which is collected is to classify the obstacles if they are real negative obstacles. This method follows is the negative obstacle detector approach.

The NODR classifies potential negative obstacles by detecting gaps, an absence of data, where there could exist a ditch, cliff, or negative slope. Algorithm is based on laser sensors that produce structured results, such that vertically aligned. The first step used in the NODR method is to search for a step, a drop in elevation beyond a step threshold, that extends beyond the gap distance. The gap threshold are determined by the size of a hole that would cause damage or stop the platform.[4].

The threshold value of the distance that would be expected if the next point had the same elevation as the previous point, and the vertical angle had increased by y*Δ where Δ is the vertical angular resolution between horizontal scans. The number of points is calculated by finding the viewing angle of the negative obstacle.

For ranges R that are not quite so distant, where the small angle approximation doesnot work and Equation 1 does not provide an accurate measurement of this equation is H

$$\omega = \tan^{-1}\frac{H}{R} - \tan^{-1}\frac{H}{R+\psi}$$

The number of slope points to be used is num points where Δ is the vertical angular resolution of the sensor. As long as num points is greater than 1, we can determine the back slope. When the gap is detected

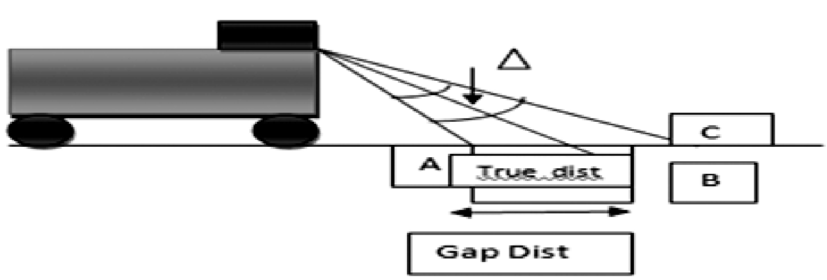

Figure 3: A gap in the potential negative obstacle

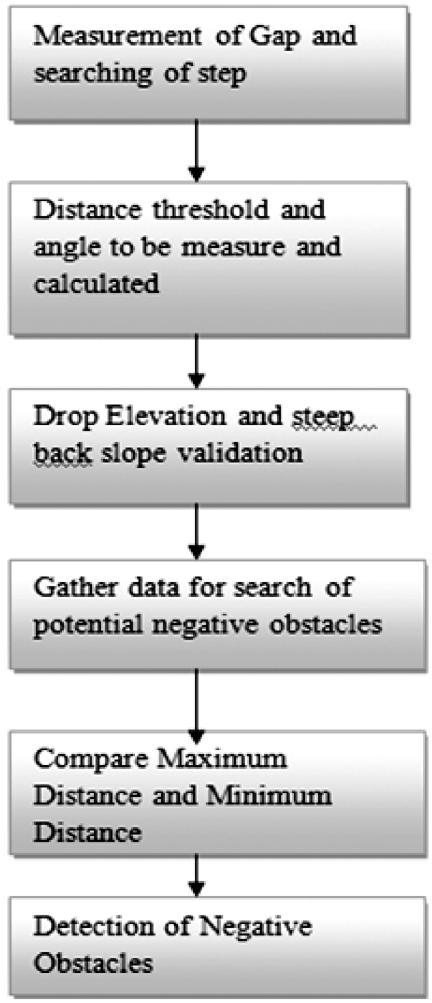

Figure 4: Diagram for NODR Classification

at ranges where a back slope is impossible to calculate because the vertical angle resolution is less than ω, it is simply classified as a potential negative obstacle.

3.3. SVM Classification Approach

SVM is the support vector machine algorithm which is a classification method which is use to separate the trained and untrained data. the support vector machine returns the vector rays in between laser points that are classified as potential negative obstacles. Parameters passed into the SVM include the range to the first point (of a pair of two vertically aligned points) from the sensor, the distance between the two points, the change in vertical angle of the two points (as if the second point had the same elevation value as the first point) in reference to the vertical angular resolution, and the elevation difference of the two points. The SVM is trained by many samples of ground truth vector rays of negative obstacles as well as non-negative obstacles, then takes in each pair of vertically aligned points from the test cases to determine its classification.

3.4. Negative obstacle classification

Potential negative obstacle rays that begin between Dist min and Distmax are considered real negative obstacles. This is a very short distance to react to a real negative obstacle, but the navigation module should have already slowed down for the potential negative obstacles as it was approaching them (the speed should be slow enough to allow stopping distance before the obstacle, using Equation

$$\text{Dist}_{\min} = \frac{H}{\tan_{(\max)}}$$

$$\text{Dist}_{\min} = \frac{H}{\tan_{(\min)}}$$

Where, $\tan_{max}$, $\tan_{min}$

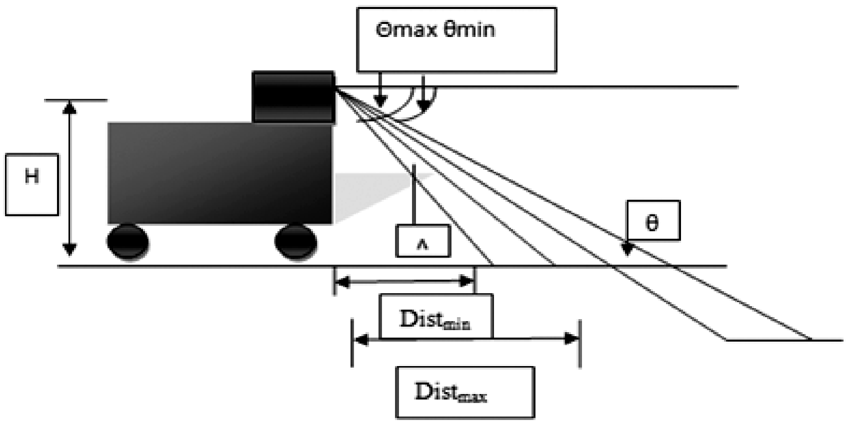

Figure 5: Sensor Angles for Max and Min Distance

The Proposed approach which uses the different classification method such as NODR classification detector gives the data clustering and analyze the data which is very close to search and detect that if it is a true negative obstacles. To detect the potential negative obstacles the data is been gathered and analyze the real data and labeling of the data is been to detect the potential negative obstacles. The method is based on geometry data for detecting negative obstacles.

Difficulty in detecting negative obstacles, this classification method errs on the side of generously detecting negative obstacles and then labelling them as only potential negative obstacles. NODR is a vector ray between two laser points that can be used to populate a grid map of obstacles and proposed method is to slow down when these potential negative obstacles are in the immediate navigable path, and avoid them once they have been truly classified.

SVM approach is the classification approach which is used to classify the potential negative obstacles based on the vector rays of the range svm gives the range of the rays to the first point which is vertically aligned rays of rays to the sensor.svm is the approach which is trained by various samples of vertically aligned points.

Negative obstacle classification is the method for the elevation of the values of the within the narrow ranges of rays to the true negative obstacles. calculation of the range is done on the data based on the maximum negative slope.

4. PARAMETER USED FOR CLASSIFIACTION

Various parameter used for the negative obstacle classification are as follows: Maximum negative slope is given for the calculation of the ranges and the measurement of the vertical an done from the sensors. Potential negative obstacles are detect rays which are between the Dist_{min} and Dist_{max} and this are the two real negative obstacles. Sensors angles are the parameters which are used to find the minimum and maximum distance for the negative steep measure.

5. RESULTS

Type of Lidar	*Classification Approach*	*Range*	*Rays Detected (%)*	*Obstacle Detected (%)*
Small	NODR	20m	50	78
Large	SVM	13m	53	89

6. CONCLUSION

Obstacle detection for the safe navigation using 2D Lidar sensor data is used for the applications in different fields. Negative obstacle detection is done by the use of classification method i.e. Negative Obstacle Detector approach and Support Vector Machine approach is used to find the distance of the range which is based on the maximum negative slope which gives the range of the rays of the negative obstacles. NODR is used to classify the data gathered by the potential negative obstacles and labeling of the data is been done to detect if are true. Negative obstacles are difficult to detect, this classification techniques are used for the detection of negative obstacles which are for the off road under ground obstacles.

REFERENCES

[1] Yan Peng, Dong Qu , Yuxuan Zhong, Shaorong Xie, Jun Luo Ja-son Gu The Obstacle Detection and Obstacle Avoidance Algorithm Based on 2-D Lidar Proceeding of the 2015 IEEE.

[2] Ho-Hsing Hsieh, Chi-Yao Hsu, Po-Yu Ke, Guang-Sheen Liu, Chih-Ping Lin Appling Lidar-Based Obstacle Detection and WirelessmImage Transmission System for Improving Safety at Level Crossings2015 IEEE.

[3] Pierre-Luc Richard, Nicolas Pouliot and Serge Montambault, Introduction of a LIDAR-Based Obstacle Detection System on the Line Scout Power Line Robot 2014 IEEE.

[4] Jaehyun Han, Dongchul Kim, Minchae Lee, and Myoungho Sunwoo, Enhanced Road Boundary and Obstacle Detection Using a Downward-Looking LIDAR Sensor IEEE Transactions on Vehicular Technology, VOL. 61, NO. 3, March 2012

[5] Michael S. Darms, Paul E. Rybski, Christopher Baker, and Chris Urmson Obstacle Detection and Tracking for the Urban Challenge IEEE Transcations on intelligent Transportation Systems, VOL. 10, NO. 3, September 2009.

[6] Jacoby Larson and Mohan Trivedi, "Lidar Based O_-road Negative Obstacle Detection and Analysis" International IEEE Conference on Intelligent Transportation Systems Washington, DC, USA. October 5-7, 2011.

[7] Volkan Sezerand and Metin Gokasan, A novel Obstacle Avoidance Algorithm "Follow the Gap Method" Robotics and Autonomous Systems 60 11231134 2012.