Path Planning of an UAV with the Help of Lidar for Slam Application

C Aakash¹ and V Manoj Kumar²
¹ Post-Graduate Student, Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India.  
² Assistant Professor (Sr. G), Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India.

E-mail: ac7769@srmist.edu.in

Abstract. Today's world there will be always a value for path planning. Be it the use of mobile robots such as UAVs, UGVs, USVs, etc., everything functions based on SLAM input. The input parameter can be extracted by any kind of sensors such as Kinect, LiDAR, etc. Here I am using RPLIDAR(LiDAR) as Sensor for UAV path generation. By getting a single Plan reading from lidar I will generate 3D mapping by a gazebo and visualize it by rviz in ROS. Here we use ROS as an interface of robot and sensor.

1. Introduction

The advantages of implementation of Unmanned Aerial (Air) vehicles (UAVs) at both civil and military applications have raised worldwide interest. Using UAVs in rescue operations, surveillance operations, delivery operations, launch and retrieval [1] operations will reduce cost and causality risks. And also, the involvement of humans will be reduced. Thus, human error will be reduced. These autonomous vehicles need to sense the environment and localize itself according to its dimension and design. Then map the available free space [2]. Then generate waypoints according to any waypoint algorithm [3]. Then travel towards the goal. A (UAV) unmanned aerial vehicle is a carrier less a commercial trial-ready and a sort of unmanned vehicle (figure 1). UAVs are a part of a man less air framework structure, which fuses a UAV, a ground-built controller, and a course of the act of trades between the two. The outing of UAVs may work with different degrees of opportunity either under remote control by a human executive or independently by introduced PCs. Appeared differently with a looked after aircraft, UAVs were at first used for missions too much "dull, unsanitary or hazardous" for individuals. While they started generally in military applications, their usage is rapidly reaching out to business, sensible, recreational, agricultural, and distinctive applications, (e.g.,) policing and surveillance, thing movements, ethereal photography [10], pilfering, and robot running. Non-military workforce UAVs now incomprehensibly predominate military UAVs, with appraisals of over a million vended by 2015.

Path planning is a term used in mechanical innovation is to find a way of real plans that moves the robot from the source to objective [8]. For example, consider investigating a compact robot inside a structure to an ousted way-point. It ought to execute this errand while maintaining a strategic distance from dividers and not tumbling the first floor. An advancement arranging calculation would take a delineation of these undertakings as information, and produce the speed and turning headings sent to the robot's wheels. Improvement organizing calculations may address robots with a more prominent
number of joints, legitimately complex undertakings, various essentials, and shortcoming. Way arranging has a couple of robotic applications, for instance, self-administration [4-7], motorization, and robot structure in PC helped configuration programming [9], similarly as applications in various fields, for instance, animating propelled characters, PC game, mechanized thinking, building plan, automated medical procedure, and the investigation of natural particles. A fundamental path planning issue is to deliver a ceaseless movement that associates a start setup S and a Goal design G while maintaining a strategic distance from a crash with acknowledged restrictions [11]. The computer and deterrent dimensions are portrayed in a 2-Dimensional or 3-Dimensional workstation, while the movement is spoken to as a way in (conceivably higher-geometrical) arrangement space.
2. Methodology

![Figure 2. Work Flow.]

2.1. Localization
The initial step of any path planning operation is going to be localization. In this project, the dimensions of the quad-copter will be given to the middleware via design (figure 2). Thus, the localization of our UAV took place in this paper.

Mapping: In this project the environment is going to be mapped by the LiDAR sensor for a single plane reading then it will be ready for the whole environment in 3d by moving the drone in a vertical direction and the 3D simulator in our middleware will generate a 3d reading of the environment under our sensors limit.

Waypoint generation: Usually, path planning will be done by generating all possible waypoints and selecting the optimal short path for the autonomous aerial vehicle. As it here too the waypoints will be generated in the available airpath which is all free from obstacles which we found from Mapping.

Path Planning: Usually, path planning will be done by one are more path planning algorithms here I planned to use some path planning algorithms given below,

- Green Fire Algorithm
- Dijkstra Algorithm
- A*(A-star) Algorithm
2.1.1. Green Fire Algorithm

Step1: Map the environment in a grid and fix obstacle covered node as shaded one.

Step2: Start and Goal (0) nodes will be noted.

Step3: Other nodes will be numbered as the distance between goal and it’s added by one.

Step4: Select the path by following the smallest number other than the past position.

2.1.2. Dijkstra Algorithm

Step1: Map the environment in Graph and distance between each individual will be noted.

Step2: Start (0) and Goal nodes will be noted.

Step3: All possible paths will be compared and a short distance from a starting position will be denoted in the node.

Step4: Then go along with path marked with a small number and Continue Step3.

Step5: Continue Step4 until you reach Goal.

2.1.3. A*(A-star) Algorithm

Step1: Map will be framed Graph.

Step2: Distance between individuals and direct (heuristic) distance will be noted.

Step3: Heuristic distance added by individual distance from the Starting point, will be marked in nodes.

Step4: Nodes with a small number will lead Step3 again.

Step5: Continue Step4 until you reach Goal.

3. Hardware

3.1 RPLIDAR A1-M8

RPLIDAR depends on laser triangulation ranging principle and usages fast apparition securing and handling equipment created by SLAMTEC. The framework measures separation information over 2000 times each subsequent and with high-goals separation yield. RPLIDAR transmits a balanced infrared laser signal and the laser sign is at that point reflected by the article to be recognized (table1). The chronic sign is examined by the vision securing framework in RPLIDAR A1 and the DSP installed in RPLIDAR A1 starts handling the example information and yield separation worth and point an incentive in-between article and RPLIDAR A1 along with the correspondence interface (figure 3).
Figure 3. RPLiDAR A1-M8.

The rapid ranging scanning system is mounted on a turning whirligig with work in the rakish encoding scheme. During pivoting, the 360-degree sweep of the present condition will be done. The LIDAR scan image is not directly relative to the environment showed here. Illustrative purpose only.

Table 1. RPLiDAR A1-M8 Specifications.

| Item                 | Unit          | Minimum | Typical | Maximum |
|----------------------|---------------|---------|---------|---------|
| Distant range        | Meter (m)     | TBD     | 0.15 - 6| TBD     |
| Angular range        | Degree        | n/a     | 0 - 360 | n/a     |
| Distant Resolution   | mm            | n/a     | < 0.5   | n/a     |
| Angular Resolution   | Degree        | n/a     | <= 1    | n/a     |
| Sample Duration      | millisecond   | n/a     | 0.5     | n/a     |
| Sample Frequency     | Hz            | n/a     | >= 2000 | 2010    |
| Scan rate            | Hz            | 1       | 5.5 (while taking 360-degree reading) | 10 |

3.2 Quadcopter

The quadcopter is widely used in our world for several Applications. Making a drone’s hovering is not as easy as building the drone. The major components required to build a UAV are the frame, blde motor, ESC, propeller, flight controller, etc. One should calculate the net weight and thrust ratio before choosing those components.

3.3 Sample Testing

The test was held in an indoor environment after assembling the drone and fixing the lidar sensor with the UAV. Thus, the indoor environment is mapped in Rviz (Robot Visualiser) (figure 4). The I2C communication between the sensor’s controller (Raspberry pi) and the flight controller (ArduPilot) should be improved in future works. Thus, sample testing is done successfully.
4. Conclusion
Considering the general objectives of this work, which is, to obtain the shortest path from the available waypoints created by Obstacle detection generated by the LiDAR results are satisfactory. The tests were conducted in an indoor environment composed of different places. The drone (UAV) traveled correctly from the initial position to the goal position accurately. The results obtained from the experiment shows that this approach is feasible and efficient. As future work, higher amplitude hovering, high range sensors, and computer vision technology will be applied for location tracking and identifying the environment more precisely.

5. References
[1] Tang Y, Hu Y, Cui J, Liao F, Lao M, Lin F and Teo RS 2018 Vision-aided multi-UAV autonomous flocking in GPS-denied environment IEEE Transactions on industrial electronics 66 616-26
[2] Madhavan TR and Adharsh M 2019 Obstacle Detection and Obstacle Avoidance Algorithm based on 2-D RPLiDAR In2019 International Conference on Computer Communication and Informatics 1-4 IEEE
[3] Xuexi Z, Guokun L, Genping F, Dongliang X and Shiliu L 2019 SLAM Algorithm Analysis of Mobile Robot Based on Lidar In 2019 Chinese Control Conference (CCC) pp 4739-4745 IEEE
[4] Ni W, Sun G, Pang Y, Zhang Z, Liu J, Yang A, Wang Y and Zhang D 2018 Mapping three-dimensional structures of forest canopy using UAV stereo imagery evaluating impacts of forward overlaps and image resolutions with LiDAR data as reference IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 11 3578-89
[5] Ohya I, Kosaka A and Kak A 1998 Vision-based navigation by a mobile robot with obstacle avoidance using single-camera vision and ultrasonic sensing IEEE transactions on robotics and automation 14 969-78
[6] Yu H, Meier K, Argyle M and Beard RW 2014 Cooperative path planning for target tracking in urban environments using unmanned air and ground vehicles *IEEE/ASME Transactions on Mechatronics* **20** 541-52

[7] Adams MD 2000 Lidar design, use, and calibration concepts for correct environmental detection *IEEE Transactions on Robotics and Automation* **16** 753-61

[8] Kim G, Park B and Kim A 2019 1-day learning, 1-year localization: Long-term lidar localization using scan context image *IEEE Robotics and Automation Letters* **4** 1948-55

[9] Fernandez-Diaz JC, Glennie CL, Carter WE, Shrestha RL, Sartori MP, Singhania A, Legleiter CJ and Overstreet BT 2013 Early results of simultaneous terrain and shallow water bathymetry mapping using a single-wavelength airborne LiDAR sensor *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* **7** 623-35

[10] Yang B and Chen C 2015 Automatic registration of UAV-borne sequent images and LiDAR data *ISPRS Journal of Photogrammetry and Remote Sensing* **101** 262-74

[11] Sarda EI and Dhanak MR 2016 A USV-Based automated launch and recovery system for AUVs *IEEE journal of oceanic engineering* **42** 37-55