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UAV Photogrammetry and Lidar Mapping

Vaisakh Anand, Karthik R J, Vishnu Dathan, Ram Prasad Tripathy

(Dept. of EC, LMCST, Kuttichal)

Abstract: The project aims at designing a Quad-Copter that can fly into a environment and prepare a 2D scaled map as well as a 3D map of the of its surrounding. The 2D map is blue print of the surrounding which is scanned and plotted by a distance measuring sensor which uses pulsed lase light. The 3D output is made possible with the help of photogrammetry process of the images captured by the camera. Quad-copters, generally use two pairs of identical fixed pitched propellers; two clockwise (CW) and two counter-clockwise (CCW). These use independent variation of the speed of each rotor to achieve control. The quad-copter are the best UAV designs that are efficient for both outdoor and indoor flight. The UAV can be used for civilian surveying to military forefront scanning, and everything in between. Its output can be used for creating database of the city for autonomous car and self-navigated vehicles. 3D map of the environment will help us scan the outdoor and give full scaled 3d models of monuments and building.

Index Terms—LIDAR mapping, LIDAR, 3d photogrammetry, ROS, RVIZ, OpenDrone Maps.

I. Introduction

The military use of unmanned aerial vehicles (UAVs) has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. The larger UAVs also provide a reliable long duration, cost effective, platform for reconnaissance as well as weapons. They have grown to become an indispensable tool for the military.

Through this paper, we look forward towards bringing these UAV's and their abilities to the common man. Here using these UAV's we brought LIDAR mapping and photogrammetry processes, which were once used by military and other scientific research centers for advanced robotics. Our output can be used for many commercial as well as non-commercial areal mapping.

For aerial mapping of both indoor and outdoor environments, we had to opt for a design that is both stable in confined spaces as well as in turbulent open spaces, hence a quad-copter. Throughout the making, we aimed for using existing systems and open source software so that our users could easily understand and work with our environment to make necessary changes.

The quad-copter is able to map its surroundings as it flies. Consider the quad-copter flying into an unknown hostile environment, it maps the surroundings and send the processed data over to a remote pc used by the user. The processed data include a dynamically updating map and a live video feed over which Facial Recognition system (FRS) is ran.

This map, the LIDAR map, that is obtained by the quad-copter can be used by autonomous robots as a basic blueprint for their navigation protocols. The very same map can be used to calculate the total area of the floor, or to get a blueprint of the floor. The data that is obtained can be used for many purposes, from surveying to military fore-front warning systems.

Even though there are systems that are available, which could 3D map the outdoor environment and show everything from surface analysis to vegetation data, their complexity and unavailability of data formats prevent developers from using them. Through this paper, we aim at providing small scale, economic mapping solutions for developers.

The drone is actually controlled by two boards, one being the flight controller (ATMEGA 328) and the other being a Raspberry pi 3. This dual control over the system is what makes the drone special. The onboard flight controller is real-time, which makes it best suitable for flight control, but reduced processing capabilities. The raspberry pi 3 is used to process the sensor data, plot the cloud points, run FRS over the camera visuals, and all the other mid air processes.

II. LITERATURE SURVEY

A. LOAM: Lidar Odometry and Mapping in Real-time

Ji Zhang and Sanjiv Singh proposed a system of accurate measuring the environment with a 3d lidar and using Lidar odometry. Taking the brilliant method of mapping and omitting out the odometry part, we created this device with approximation from overlaying laser scanned images to plot the cloud points and measuring the change in angle through the correlation between the laser scan data.

B. RANGE - Robust Autonomous Navigation in GPS-denied Environments

Here the team proposed an idea of using laser scanner, IMU, stereo cameras for autonomous navigation. From this paper we came to know the basics for autonomous navigation. But through this paper we propose a system that could navigate autonomously from the laser scan data of the Rplidar unit alone. The use if IMU and stereo camera is omitted.

III. PROPOSED METHOD

WHAT IS LIDAR?

LIDAR, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. The principle behind LiDAR is really quite simple. Shine a small light at a surface and measure the time it takes to return to its source.

Light travels very fast - about 300,000 kilometres per second, 186,000 miles per second or 0.3 metres per nanosecond so turning a light on appears to be instantaneous.The equipment required to measure this needs to operate extremely fast. Only with the advancements in modern computing technology has this become possible.

The actual calculation for measuring how far a returning light photon has travelled to and from an object is quite simple:

Distance = (Speed of Light x Time of Flight) / 2

The LiDAR instrument fires rapid pulses of laser light at a surface, some at up to 150,000 pulses per second. A sensor on the instrument measures the amount of time it takes for each pulse to bounce back. Light moves at a constant and known speed so the LiDAR instrument can calculate the distance between itself and the target with high accuracy. By repeating this in quick succession the insturment builds up a complex 'map' of the surface it is measuring.

THE MAPPING PROCESS:

To get a 2D scaled map of the environment we need plot the points of the distances that are given by the lidar unit, at same time, as the sensor is on the move, the sensor’s position in relation with the environment also required. Hence we use the SLAM algorithm for 2D mapping.

To create a 3D map of the environment, we use the photogrammetry technique. Photogrammetry is the science of making measurements from photographs. The output of photogrammetry is typically a map, a drawing or a 3D model of some real-world object or land mass.

DATA PROCESSING AND ACQUISITION

The raw data from the LIDAR can be either send to a remote computer for processing, or can be processed on board. We chose to process it with a onboard Rasperry pi 3. We did so because, we saw a big scope on making the drone autonomous in the future.

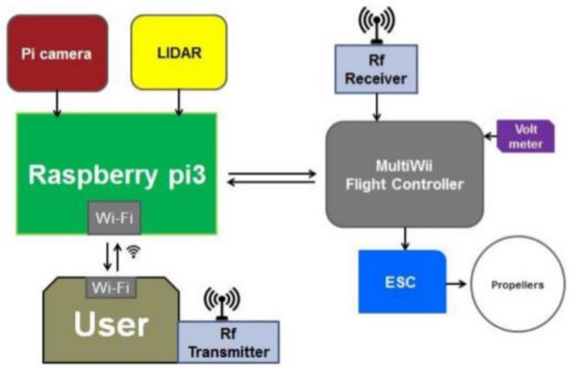

Figure 1: Data Processing Architecture

On the raspberry pi 3, we ran ROS (robotic Operating Ssystem) for processing the data and plotting the map with Hector-SLAM algorithm. Through ROS we could achieve nearly perfect maps with our RpLidar unit. The best part with working in ROS is that we could run many nodes altogether, with each nodes communicating with each other. Each node has their own purpose, as if one node stores the scanned laser points in one array, another plots it as cloud points, another one would be running the hector slam algorithm so that it can do image processing over the cloud points to map without odometer, etc.

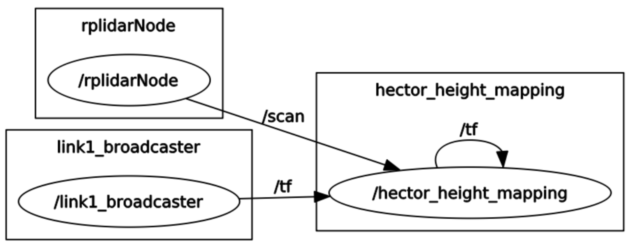

Figure 2: Internode Communication

Instead of using the raspberry pi to control the brushless motor, we used a MultiWii Crius SE 2. Apart from having its own onboard gyroscope, barometer and accelerometer, we needed a rapid responsive system to control the quad, i.e. a real-time controller. As raspberry pi isn’t real-time we used MultiWii flight controller for flight control. Now that a different board controls the flight, we could do hectic processes on our raspberry pi and at the same time control the quad with a conventional RC.

There were even options to transmit the sensor data to a remote pc, but doing so, would have let us to a point where, 3D photogrammetry and FRS been processed over an video broadcast from an onboard camera.

IV. PROPOSED ALGORITHM

When it comes to mapping the environment, the biggest challenge we faced was to map without a using odometer. In most algorithms, mapping needs the laser scan data and the odometry so as to accurately plot the cloud points. Hence we used the SLAM algorithm.

SIMULTANEOUS LOCALIZATION AND MAPPING (SLAM)

In robotic mapping, simultaneous localization and mapping (SLAM) is the computational problem of constructing or updating a map of an unknown environment while simultaneously keeping track of an agent's location within it. While this initially appears to be a chicken-egg problem there are several algorithms known for solving it, at least approximately, in tractable time for certain environments. Popular approximate solution methods include the particle filter and extended Kalman filter.

SLAM algorithms are tailored to the available resources, hence not aimed at perfection, but at operational compliance.

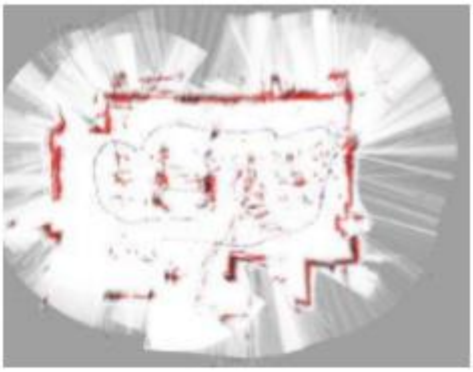

Figure 3: A typical hector-slam output.

DRONE PHOTOGRAMMETRY

To create 3D maps from aerial photogrammetry, the camera is mounted on the drone and is usually pointed vertically towards the ground. Using photogrammetry to create 3D models of monuments or statues, the camera is mounted horizontally on the UAV.

Multiple overlapping photos (80 to 90% overlap) of the ground or model are taken as the UAV flies along an autonomous programmed flight path called awaypoint. To overlap photos of an object or land by 80 to 90% would be impossible to complete accurately by pilot navigation. It is essential to have a UAV which has waypoint Navigation technology. Here, photogrammetry is done with open source software the Open Drone Map

V.SIMULATION RESULTS

Hector-slam algorithm implemented through ROS. Here the lidar scan data is sent from the Rplidar to the raspberry pi serially. The data from the laser scans is then plotted with hector-slam algorithm to map the environment through which the quad-copter flies. Below are the screen shots f running the sensor scan data on a PC so as to fully visualize the procedure that is followed in the raspberry pi.

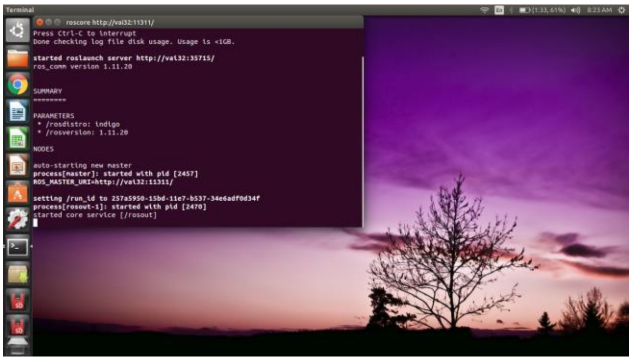

Figure 4: Runnning Roscore

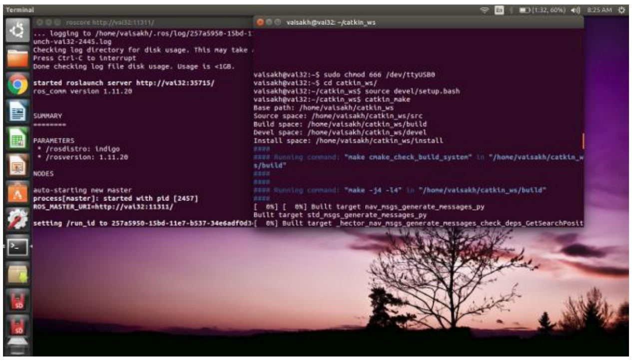

Figure 5: Giving permission to USB port and sourcing the work folder

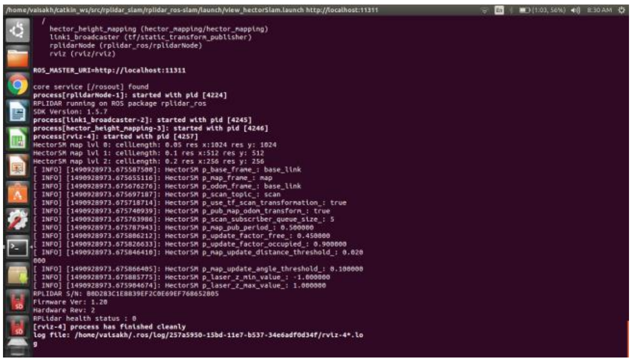

Figure 6: Running the launch file for hector_slam mapping

Roscore is ran on a terminal which will instiaise the ROSCORE for running ros. Then we give the sensor USB port its permissiong and make our catkin workspace. After we run our launch file which give the Rplidar its initilaise commands and then starts to plot the clound points that are provided by the rplidar

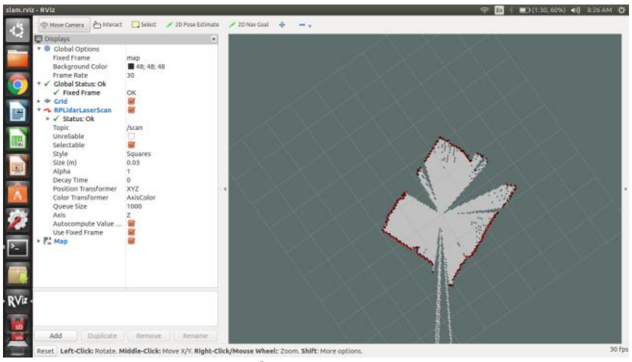

Figure 8.1: The Hector-SLAM map on Rviz

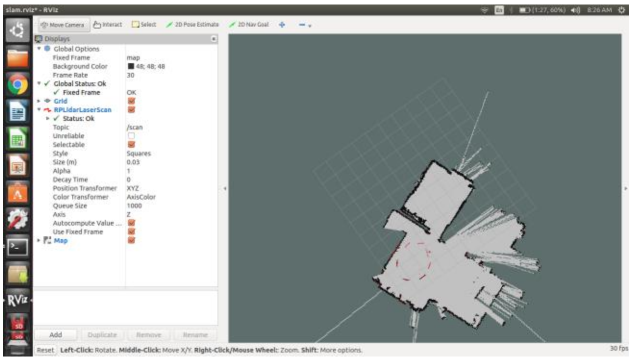

Figure 8.2: The Sensor maps as we move and cover larger area

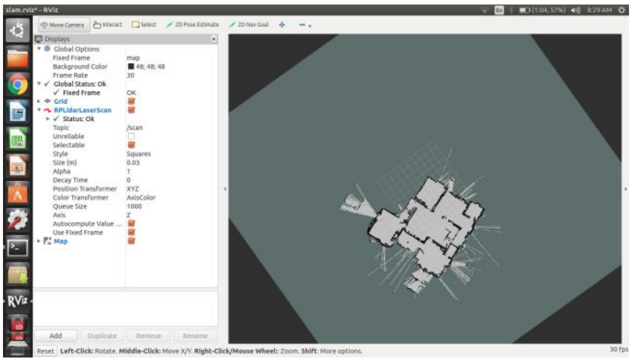

Figure 8.3: The Full MAP that is maped using the LSER SCAN DATA with Hector-SLAM algorithm

VI CONCLUSION

The project is a success and is well aimed at developers for developing their methods and implementing autonomous bots, as well as to bring in complex technology to the common public so that they could use it for their ease. We aim to develop this project to a point where our Quad-copter could fly autonomously with the recorded data, as all the provisions needed for doing so is open.

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