Aerial Assistance for Sensorless Vehicles

Independent Project for ME 530.707 Robot Systems Programming, Spring 2017

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Introduction

Vehicle planning in uncertainty is a trending topic. The need for planning and navigation in unreliable environments has greatly increased with the development of artificial intelligence algorithms and computing machinery.
One of the most challenging tasks in motion planning is the awareness of the existing surrounding. The absence of a 6dimensional degree of freedom makes navigation with ground robots harder. Also, in scenarios where the navigating subject is not a robot, but rather a person driving a vehicle, the absence of depth sensors makes navigation and mapping highly challenging. Also trending is the need for different robotic systems to communicate with each other, sharing information to a mutual benefit.
Our project “Drone Slam” presents a simple solution of navigation for ground vehicles in uncertain terrain.

Proposal:
In this project we seek to map and localize the 3d environment with the help of an aerial vehicle. The map is then utilized by a crude robot with just odometry information to navigate from one point to another whilst avoiding obstacles.

We use AR tags as a substitute for features for mapping the environment but one can substitute the AR tags with features like SIFT, SURF to map the surroundings [1]. The map generated is then used by an Edumip to intelligently navigate by avoiding the obstacles. We do away they need for a continuous localization of the edumip by means of accounting for its odometry. Path planning is done with the help of move_base library.

Fig 1. shows our map building 3d structure and shows the occupancy grid for the particular environment mapped by the drone. Fig 4. shows the movement of the edumip from an initial state to a goal state taking into consideration of obstacles in the surroundings.

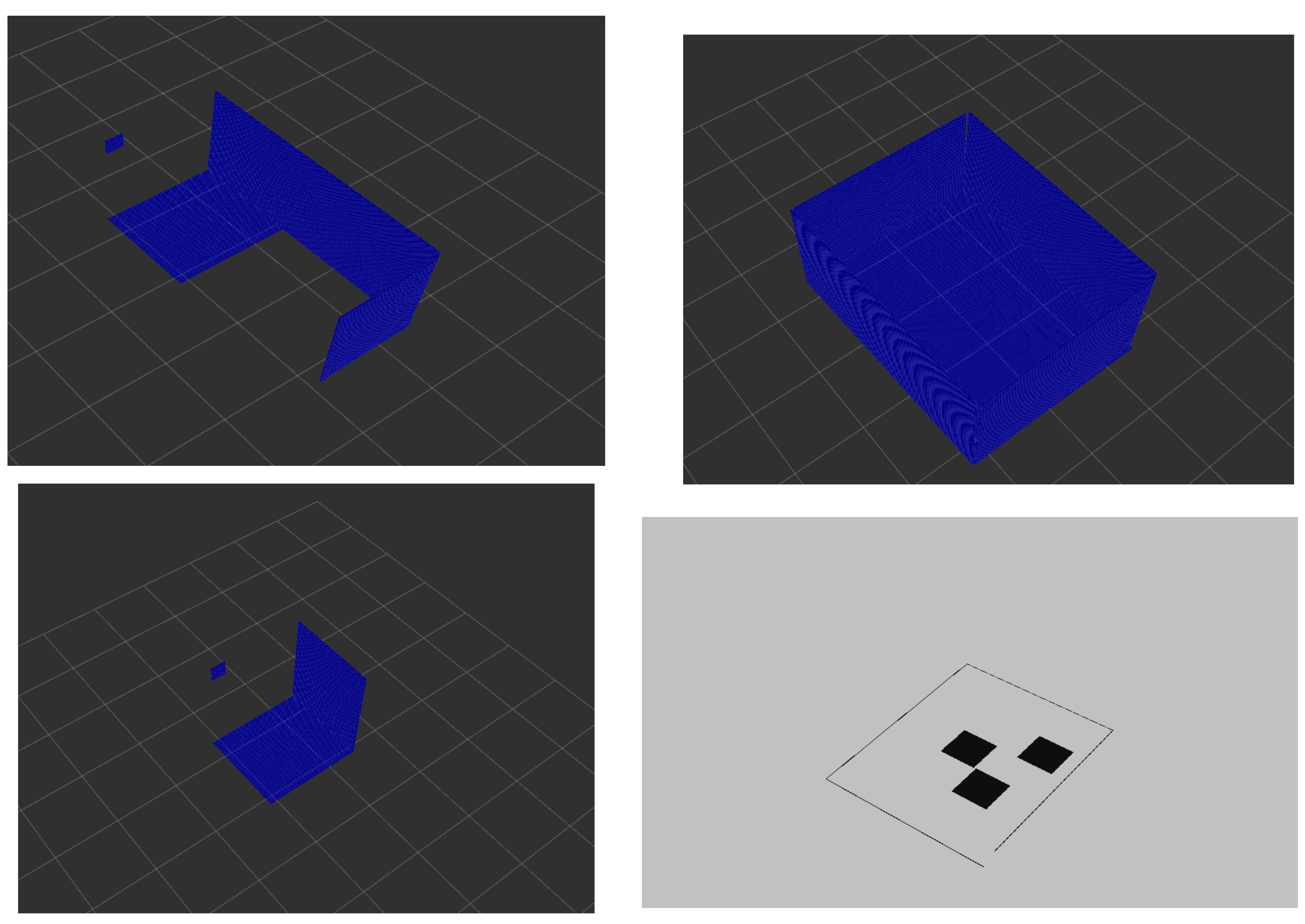

Figure 1. Clockwise from top right, stages of reconstructing a cuboidal room and the occupancy grid showing the obstacles on the ground plane of the room

Hardware and Infrastructure

Existing available hardware employed by this project include the following:
1. Edumip – Designed by Dr. James Strawson and ROSified by Dr. Louis Whitcomb. Fig
2. Ar Tags generated by ar_track_alvar – ROS wrapper for Alvar, an open source AR tag tracking library
3. Logitec Joy Stick – Low cost multi purpose joystick for teleoperating the drone
4. Beagle Bone Black – Low cost community supported hobby/ research development board
5. Robotics Cape – Developed by strawsondesign, provides imu rich interface with beagle boards

New hardware purchased for this project include the following:
1. Parrot Ar Drone 2.0, a low cost drone developed by parrot

a. b.

Fig 2. a. Parrot ArDrone 2.0 , b. EduMip

Fiigure 3. Prototype for testing the package. We assume the cage represents a cuboidal room and the AR Tags [red squares]are the visual landmarks. (Drone shown by yellow ellipsoid)

Software

Existing available software employed by this project include the following:
1. Ar_track Alvar – ar tag tracking package for ros [http://wiki.ros.org/ar_track_alvar]
2. Ar_drone Autonomy – Ros driver for ar drone [https://ardrone-autonomy.readthedocs.io/en/latest/]
3. Gazebo – Simulation software with realistic physics engine [http://gazebosim.org]
4. Eigen – C++ Math Package, helps in easy matrix operations [http://gazebosim.org]
5. ROS – Multithreaded package provides easy and convenient interfacing with robotic systems [http://eigen.tuxfamily.org/index.php?title=Main_Page]
6. Ros Navigation Stack – Move Base, amcl and fake Localization [http://wiki.ros.org/navigation]
7. Edumip software – Developed by Strawson, ROSIFIED by Dr. Louis Whitcomb [https://dscl.lcsr.jhu.edu/ME530707_2017_EduMIP_ROS]

New software that we designed and coded for this project include the following:
1. Enironment Detection
2. 3D Reconstruction Package
3. Occupancy grid estimation
4. Ar Drone joy package
5. Gazebo adaption of the real scenario

Procedure

1. The AR Drone takeoffs from an arbitrary location and moves around searching for visual indicators whose transform it can estimate. As soon it finds the first landmark, it will choose that to be the base frame for the map.
2. Subsequently, it tries to see visual landmarks in the environment and get their relative configurations with respect to each other.
3. Eventually we have a network of transforms, from which we can extract a crude 3D reconstruction of the environment. More the number of markers, the better the reconstruction.
4. Additionally, if the AR Drone sees a landmarks it has already seen, it can localize itself using the current relative configuration.
5. The AR Drone identifies certain markers on the ground plane to be obstacles. It also creates an occupancy grid of these, along with the boundary of the surroundings.
6. With all these things, the Edumip can be given a trajectory to follow which is collision free and takes it to a desired pose.
7. The Edumip, which has no information about its surroundings ,cannot by itself , find a collision free path. But now by virtue of the drone’s mapping it can.

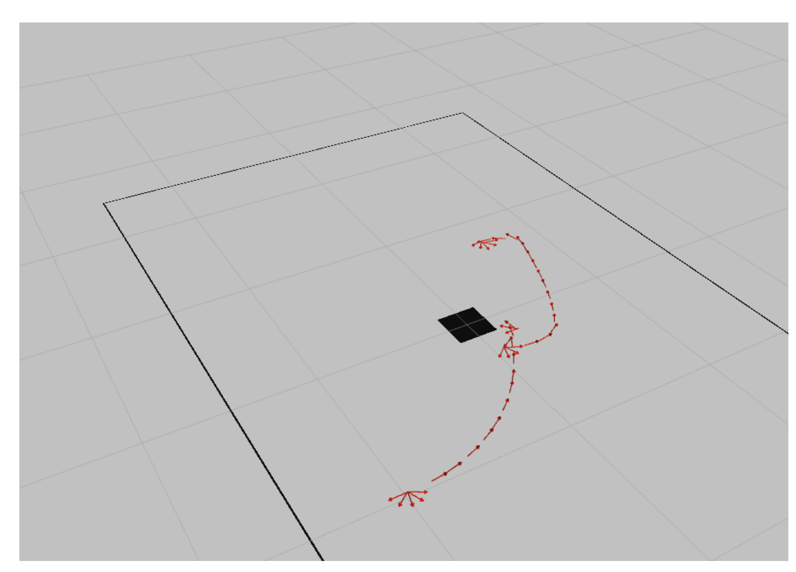

Figure 4. Path planned by move base that navigates the Edumip around the obstacle

Lessons Learned and Suggestions for Future Projects

- Testing on real hardware is not the same as simulation
- Being aware of time stamps can make or break your program.
- Using plugins to fake sensor data can be a smart hack.
- Be careful when using AR Drone
- DO not rejoice if it works in simulation. Gazebo is highly idealistic.
- Parrot AR Drone 2.0 is not a developer’s drone. It has very less modularity and functionality. Do not use both its cameras together, you will get into trouble.

Probable Applications

1. In a warehouse, where a central robot is aware of the entire map of the surroundings and sends motion plans to warehouse robots.
2. If a driverless car has a busted sensor, an aerial drone can help it get safely to a location without any harm.
3. In defense applications, a central drone can get a map of the terrains and provide a motion plan for unmanned ground vehicles.

References Cited

1] Engel, Jakob, Jürgen Sturm, and Daniel Cremers. "Scale-aware navigation of a low-cost quadrocopter with a monocular camera." Robotics and Autonomous Systems 62.11 (2014): 1646-1656.
[2] Berat A. Erol, Satish Vaishnav, Joaquin D. Labrado, Patrick Benavidez, Mo Jamshidi, "Cloud-based control and vSLAMthrough cooperative Mapping and Localization", World Automation Congress (WAC) 2016,
[3] Engel, Jakob, Jürgen Sturm, and Daniel Cremers. "Accurate figure flying with a quadrocopter using onboard visual and inertial sensing." Imu 320 (2012): 240.
[4] Engel, Jakob, Jürgen Sturm, and Daniel Cremers. "Camera-based navigation of a low-cost quadrocopter." Intelligent Robots and Systems (IROS), 2012 IEEE/RSJ International Conference on. IEEE, 2012.

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