Vision based Localization and Navigation of Unmanned Vehicles in an indoor area

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Abstract

Unmanned vehicles have a wide range of applications from self driving cars to military aircrafts. Most of these applications rely on a Global Positioning System (GPS) for localization and navigation. While GPS is quite reliable outdoors, it is unreliable and inaccurate in an indoor environment. The aim of this research paper is to provide an alternative localization and navigation method for unmanned vehicles in an indoor environment. There are many alternative localization methods such as radar, camera tracking, wifi systems and vision based systems. This research project will focus on vision based localization and navigation systems using April tags as fiducial markers. This decision was made due to its low cost, better reliability, stability and ease of set up. An indoor environment was simulated using Gazebo (a 3D dynamic simulator). A Turtle bot was simulated as an unmanned vehicle. Multiple April tags were simulated as fiducial markers in the environment. These April tags provide the Turtle bot with precise pose estimate upon detection by the Turtle bot's camera. This enables precise navigation. After integrating April tags into the simulated environment, rviz (a 3D visualization tool) is used to map the simulated environment for faster and efficient localization and navigation. This research can provide insight into the merit of using fiducial markers for localization and navigation in an indoor environment.

Introduction

As time passes humanity as a race strives to build upon and out do its predecessors.In this constant race of improvement, humanity has recently set foot on the topic of unmanned vehicles. Unmanned vehicles have a wide range of applications from autonomous cars that drive on streets to the mars rover. As time passes Unmanned vehicles are getting smarter, safer and more optimized. Most of these Unmanned vehicles rely on a Global Positioning System (GPS) for localization and navigation. While GPS is a great navigation and localization system. It has its drawbacks. It is unreliable and inaccurate in an indoor environment. The GPS signals from the satellites are attenuated and scattered by roofs, walls and other objects in an indoor environment. This results in low signal strength, instability and lower accuracy. Most often a secondary sensor is required for better accuracy. This application is seen in modern smartphones. Where they use wifi signals to increase accuracy. Hence due to this reason an alternative localization and navigation system is needed.

Methodology

The aim of this research is to provide an alternative localization and navigation method for unmanned vehicles in an indoor GPS restricted environment. There are many localization and navigation methods that can be applied in such an environment such as radar, camera tracking, wifi, vision based and Artificial Intelligence systems.

The research explores vision based systems which rely on April tags as fiducial markers for pose information. The core benefit of using April tags is that they are easy to set up. They can easily be set up with the help of a printer. They are low cost, controllable, accurate, reliable and stable. Making them an ideal quick replacement for GPS in an Indoor enviornment. In order to prove the feasibility of such a methodology, an indoor environment was simulated with the help of

Gazebo (a 3D dynamic simulator). A Turtle bot was later simulated in the environment as an unmanned vehicle.Along with multiple April tags were simulated as fiducial markers in the environment.

These April tags provide the Turtle bot with precise pose estimate upon detection by the Turtle bot's camera. This enables precise and accurate navigation with little room for error. By having an April tag in the Turtle bot's camera frame, the turtle bot is able to obtain precise information about its position to the April tag. As April tags are similar to QR codes, one can have different April tags to signify different places. With the help of Blender (3D computer graphics software) 9 cm x 9cm x 9cm cubes were created with the April tag image as its texture. These models were later imported into the Gazebo world by editing the world file to include the April tag model on world startup.

Once the environment has been set up, comes the navigation part. The navigation aspect consists of two parts. First being April tag ros package and the second being custom python script. The first part April tag ros package is a ROS plugin for April tag detection algorithms. The April tag ros package is a ROS wrapper of the AprilTag 3 visual fiducial detection algorithm. It provides April tag detection and detected tags' pose information over ROS topics. The April tag Ros package takes 2 inputs from the turtle bots camera. And outputs the pose coordinates over /tf, tag detections and tag detection image ros topics. The core AprilTag 3 algorithm is also extended to allow the detection of tag bundles and a bundle calibration script (tags.yaml and setting.yaml) is provided. Continuous (camera image stream) and single image detector nodes are available. By editing and making appropriate changes to the tags.yaml and setting.yaml the user is able to use different april tags for detection.

On the other hand the custom python script is responsible for the navigation of the turtle bot itself. By connecting to the base link of the simulated turtle bot the python script is able to navigate turtle bot from point a to point b. The script also offers better compatibility as it does not depend on gazebo plugins to function. It also offers better localization and navigation due to gmaping functionality. However, the script has a higher complexity and difficulty. The script takes the results from the April tag ros package and sends them onwards to the turtle bot.

For any unmanned vehicle, the capacity to explore in its surrounding environment is very significant. Maintaining a strategic distance from perilous circumstances, for example, crashes and dangerous conditions (temperature, radiation, introduction to climate, and so on.) is prerequisite for successful exploration and navigation. This is where localization comes in. Localization using Gmapping is able to create a map of the surrounding environment. As the robot travels around the environment it maps out all the obstacles that it may face in the world. So as time passes the map becomes more accurate and the turtle bot learns to avoid obstacles. Localization can also help the robot make out locations of all the April tags in the environment giving it a better idea of its pose information at all times.

Conclusion

In conclusion it is feasible to use Vision based localization and navigation using fiducial markers such as April tags. While this method is not without its drawbacks, its advantages such as ease of set up, low cost and low learning curve make it an ideal solution to be used in areas where high accuracy is needed and GPS signals are not strong enough. This research application can prove to be very useful for Unmanned Aerial Vehicles where pose information and accuracy plays a huge factor.