Autonomous UAV Navigation in a GPS-Denied Outdoor Environment Using Discontinuous Visual Contact with Fiducial Markers

Nicholas Dunn[1] and **Zachary Schallenberger[2]**

Dr. Richard Chapman & Dr. Saad Biaz

Auburn University

[1]Columbus State University, [2]Montana State University

Introduction

The autonomous flight of Unmanned Aerial Vehicles (**UAV**s) can be paired with a visual-based navigation system using **Fiducial Markers** to navigate a course in a **GPS-denied environment**. **AprilTag** is a tested fiducial marker that functions well as a decodable fiducial marker. Previous research has tested the autonomous flight of UAVs using fiducial markers but was restricted by requiring constant visual contact with the markers. The research presented in this poster differs by evaluating the autonomous flight of UAVs using fiducial markers through discontinuous visual contact in an outdoor environment.

Terms & Technologies

Unmanned Aerial Vehicle (UAV) • an aircraft vehicle that does not have any pilots or passengers on board

Fiducial Marker • a shape/pattern that can be decoded with a camera

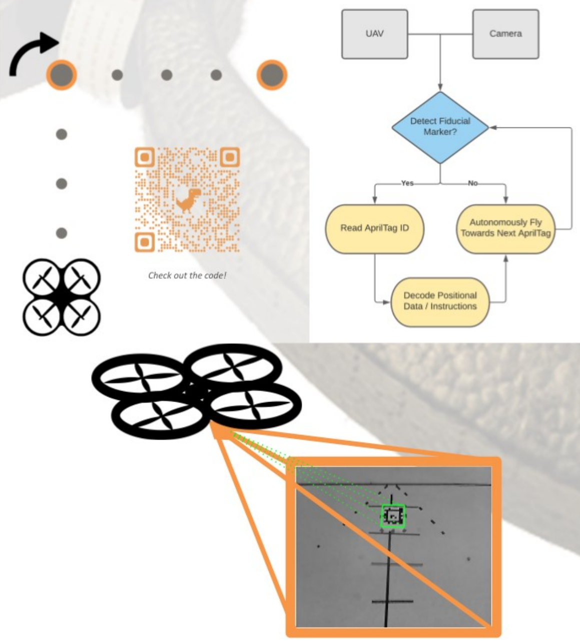
AprilTag • a fiducial marker system widely used with UAVs and UGVs

GPS-denied environment • an environment in which GPS technologies are unable to function due to exterior circumstances

Pose • the translation of a UAV (using values of all three axes) relative to a marker or particular coordinate system

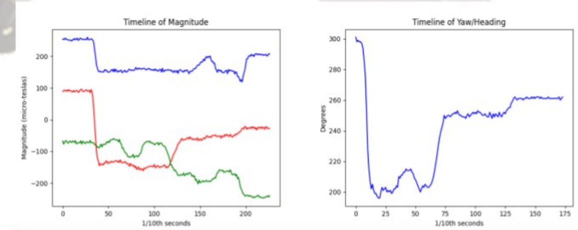
Methodology

Indoor and outdoor courses were created to validate and test an algorithm to autonomously fly a UAV using fiducial markers as instructions. The courses were designed to demonstrate the UAV's ability to navigate autonomously to a single fiducial marker, decoding its unique identification number as a set of instructions, executing those instructions, and recursively running until it detects the final fiducial marker. During the courses, the UAV began autonomously navigating, detected a marker, decoded the instructions as a change in yaw, and successfully navigated to the next/last fiducial marker.



Results

The Parrot AR.Drone 2.0 (paired with a Raspberry Pi & Raspberry Pi Camera Module v2) was successfully able to fly and detect AprilTags. The program instructed the drone to fly forward until it detected a marker, then once detected, it would decode the unique identifier of the marker as navigational instructions which it would carry out to navigate to the next AprilTag. The hardware used for this research proved to be problematic. There were both direct and indirect testing of the hardware conducted. The Adafruit LSM303DLHC magnetometer data was affected by magnetic field interference from nearby electronic devices and many parts of the UAV required constant replacement after crashes.



Conclusion

Prior research has been conducted studying different methods of autonomous UAV navigation, however, previous research required an onboard camera to have constant visual contact with at least one fiducial marker at all times. The research described in this poster uses several different technologies to evaluate the viability of autonomous UAV navigation in a GPS-denied outdoor environment using discontinuous visual contact with fiducial markers. Although autonomous UAV navigation was only partially achieved, the results are promising. The technologies implemented generally met or exceeded performance and interoperability requirements.

06/08/2021