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Intelligent GPR Semi-autonomous UAV in 3D Internal Structural Analysis of buildings

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Introduction

Structural analysis of buildings is an important task because it can reduce a possibility of catastrophic damage. When an even small crack on the wall is found, it may jeopardize the integrity of the building. Nondestructive testing methods are preferable because they don't cause any physical damage to the building. Ground penetrating radar (GPR) is a device and technique that can perform this type of nondestructive testing for the subsurface or wall. In the building survey, it has been used in analyzing internal structures to determine structural weak spots. Modern GPR devices needs human labor to perform the survey. In this work, the team has been working on finding and creating a solution using an unmanned aerial vehicle (UAV) for building structure analysis. This developing UAV with GPR would be an economical solution to measure the status of infrastructures without the interruptions of transportation, networks, water or gas systems

T3 Project Progress Overview

Three faculty members formed a triad, and this team has been working on creating an Artificial intelligence (AI) powered semi-autonomous UAV for building structural analysis. For the initial phase, we have set a flight pattern for scanning building surface as a shown in Figure 1. The details of the development progress of the UAV is described in the following section. The Ground penetrating radar (GPR) is under development. The reconstruction of 3D data is planned to be carried out after the collection of the data from the developing UAV.

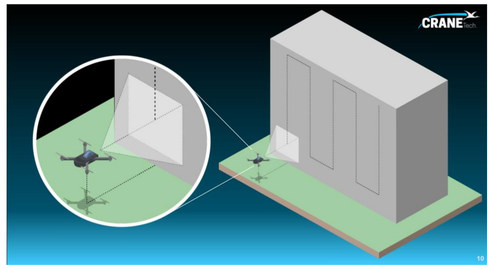

Fig 1. Building surface scanning pattern.

The team has recognized the needs of the extension of the drone that can be deployed in an underwater environment for surveying building or bridge structure. This extended effort of the underwater drone is in progress

Drone for Surveying Building Structure

The block diagram of the developing AI powered semi-autonomous drone is shown in Figure 2. This platform has a NAVIO2 and Raspberry Pi 3B+. They can make the core unit to control the drone as well as to perform Artificial intelligence (AI) tasks including image processing and crack analysis. The AI related tasks will be the next focus as the functionality of the alphas phase of the drone has been verified. The drone has several obstacle detection sensors including LiDAR and ultrasonic sensor for the autonomous flight tasks. It also has a unit to collect environment sensor data.

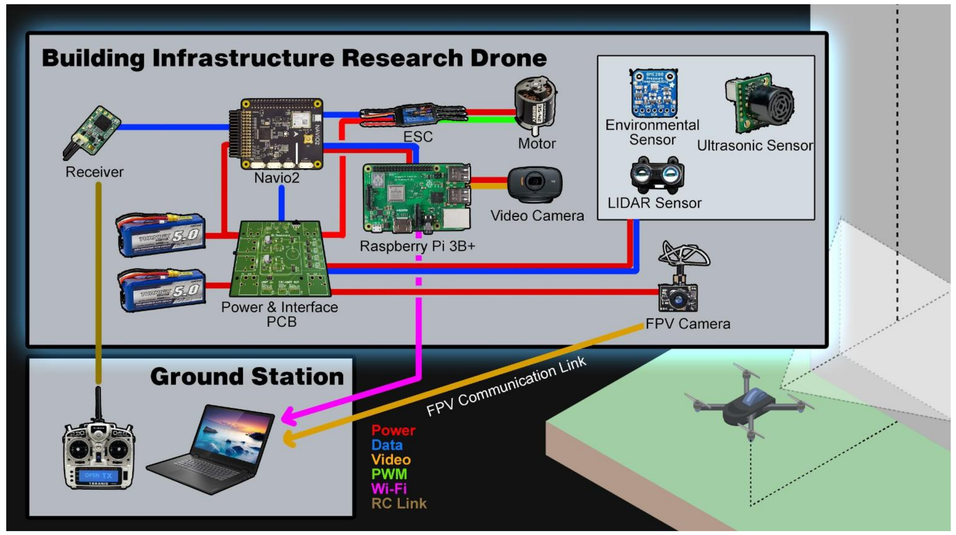

Fig 2. Block diagram of the semi-autonomous drone for building analysis.

Alpha Design Drone for building analysis and Flight Testing

Fig 3. the UAV in development Flight Testing (Left) and Aviation Control Screen (Right)

This custom UAV was designed to be safe by the protection of the propellers. This is not a small drone. The size of the wheelbase is about 650mm. The choice of the propeller is 10" 4.5 pitch propeller (1045). The propeller guards were designed and used in this quadcopter.
For the autonomous flight, ArduPilot has been used and modified to create the custom behavior of the autonomous flight pattern and for the user defined safety features

GPR and Underwater Drone

The GPR system in development is a RF test system that needs to be small and lightweight to be mounted on the drone. Moreover, a custom underwater drone for building and bridge analysis was recognized by the T3 team as a part of the structural analysis platform. It is under development. Currently, it is in the planning and designing phase.

Border and Educational Impact

T3 Team has extended the effort in creating an educational platform for building structural analysis as shown below. This system can measure strain and stress on the structure as well as to measure sensor data to be displayed on the screen.

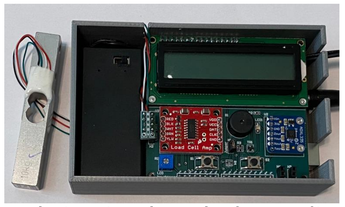

Fig 4. Educational structural analysis monitoring platform

Publication Effort and Plan

As of today, eight undergrad engineering students have been involved in this T3 project.

Regarding publications, one conference proceeding is published. One conference proceeding is in the process of publication. One journal paper is under preparation for submission.

This T3 faculty members are considering to write a grant proposal for further support of the research and development effort.

Acknowledgments

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References

[1] W. Zhan, B. Hur, B. Y. Ryoo, "A Control Systems Course Project Serving as a Bridge to a Capstone Course and Research Projects", 2020 ASEE Virtual Annual Conference