Autonomous Robotic Seismic Detection and Recording for Rugged Exploration Areas

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Abstract

Reflection seismology is commonly used for hydrocarbon exploration, which requires complex data acquisition procedures, including the placement of thousands of sensors on a large surface area. There are existing wireless recording systems for seismic exploration, which are suitable for survey areas covered by obstacles. While the wireless recording system provides acquisition flexibility, it can be improved with the automated delivery and deployment of the node to hard-to-reach places, which we implement with a UAV-based system.

The wireless systems are often referred to as nodal systems. Each node includes a radio transmitter, a GPS, a power source, and a seismic sensor. GPS is a critical technology, which is necessary to synchronously acquire real-time data from multiple nodes and provide information about precise coordinates of each node. We introduce a UAV-based Autonomous Seismic Acquisition Device (ASAD) to expand the capabilities of seismic survey. ASAD is a quadrotor with a sensor deployment system (SDS) and a landing gear capable of acquiring the data by itself and in a group.

We assembled the robot and conducted a few field experiments of the flying robot ASAD and its systems. The developed SDS provided reliable coupling between the seismic sensor and the ground. The SDS design was developed based on experimental results comparing the ground coupling using three types of SDS on the soil, sand, and gravel. The landing gear was designed to control the sensor position after landing on inclined surfaces to prevent the robot from rolling over and ensure verticality of the Z-component sensor. To set the flight mission, we developed and tested the firmware for the mission control system, which can be scaled to control a group of ASADs. Geophone and accelerometer were used to record the seismic signal. Currently the geophone is more favorable in terms of signal-to-noise ratio. However, the accelerometer records similar waveforms and is much more compact and easier to use. If the signal-to-noise performance of the accelerometer is improved (e.g., by using a sensor with a better sensitivity), it can replace the more traditional geophone and make the acquisition system smaller and lighter, which is particularly important for UAV applications.

ASAD utilized in a group can potentially lead to achieving cost-effectiveness with optimal performance through better survey execution accuracy and shorter turnaround time. It can act as a compact solution for the augmentation of the conventional seismic crew to perform specific tasks such as near-surface characterization, seismic-while-drilling, acquisition infill, passive seismic monitoring etc.