

Mission-Oriented High Resolution Near-Surface Imaging Using Swarm of Seismic UAVs

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Abstract

Land surface seismic is the most popular and efficient technique to explore, develop and monitor oil and gas reservoirs. Modern 3D land seismic acquisition is often characterized with a large number of channels, small receiver arrays and dense trace count per unit area. These improved acquisition techniques enable better vertical and horizontal resolution at target level as well as better noise characterization, which greatly improves subsurface imaging. However, the near-surface complexity that typically influences land seismic imaging quality in the Middle East still needs technological advancements. Ideally, imaging relatively shallow near-surface layers requires separate specialized survey with shorter receiver spacings and higher trace density.

We propose to address this problem on the receiver side by augmenting the conventional seismic crew with a swarm of autonomous unmanned aerial vehicles (UAV) equipped with seismic sensors. We call each of these UAVs Autonomous Seismic Acquisition Device (ASAD). The swarm of ASADs form a square patch around vibrator truck at the precomputed locations that are optimal for the minimal flight time and sufficient for accurate regular data reconstruction using compression sensing (CS) algorithms. In this case the additional high-resolution seismic survey is conducted in parallel with the conventional acquisition without requiring a separate source.

This study presents results of the initial investigations on realistic synthetic model that show how the accuracy of the near-surface image reconstruction depends on the number of ASADs and the different swarm formation. The baseline survey for ‘ideal image’ has regular grid of receivers with inline and crossline sampling of 12.5 m. The source locations were always assumed to be on the grid of 50x50 m. The formation of ASADs were simulated by extracting traces from denser 6.25x6.25 m grid (to achieve randomness required for CS) with required trace density and aperture. We studied 3 scenarios: recording with swarm of 9 ASADs on 100x100 m grid; 20 ASADs on 50x50 m grid and 100 ASADs on 25x25 m grid. Each scenario was tested with CS applied only to regularize original grid and with interpolation applied to double trace count in each direction. The seismic images of the first 500 m obtained with each simulated scenario were compared with the baseline image. Our results show that even relatively small swarm of 20 ASADs is sufficient to obtain high-resolution near-surface image.