AUTOMATED SENSOR TUNING FOR SEISMIC EVENT DETECTION AT A CARBON CAPTURE, UTILIZATION, AND STORAGE SITE, FARNSWORTH UNIT, OCHILTREE COUNTY, TEXAS

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ABSTRACT

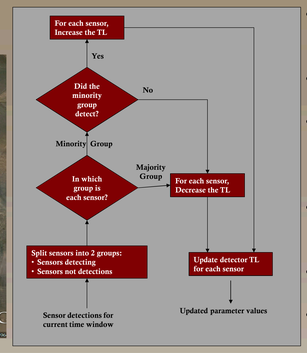
We present results (e.g. seismic detections and STA/LTA detection parameters) from a continuous downhole seismic array in the Farnsworth Field, an oil field in Northern Texas that hosts an ongoing carbon capture, utilization, and storage project. Specifically, we evaluate data from a passive vertical monitoring array consisting of 16 levels of 3-component 15Hz geophones installed in the field and continuously recording since January 2014. This detection database is directly compared to ancillary data (i.e. wellbore pressure) to determine if there is any relationship between seismic observables and CO2 injection and pressure maintenance in the field. Of particular interest is detection of relatively low-amplitude signals constituting long-period long-duration (LPLD) events that may be associated with slow shear-slip analogous to low frequency tectonic tremor. While this category of seismic event provides great insight into dynamic behavior of the pressurized subsurface, it is inherently difficult to detect. To automatically detect seismic events using effective data processing parameters, an automated sensor tuning (AST) algorithm developed by Sandia National Laboratories is being utilized. AST exploits ideas from neuro-dynamic programming (reinforcement learning) to automatically self-tune and determine optimal detection parameter settings. AST adapts in near real-time to changing conditions and automatically self-tune a signal detector to identify (detect) only signals from events of interest, leading to a reduction in the number of missed legitimate event detections and the number of false event detections.

DATA

Besides passive monitoring, the downhole array has also recorded the following seismic sources which are being evaluated for their usability in calibrating and tuning the algorithm:

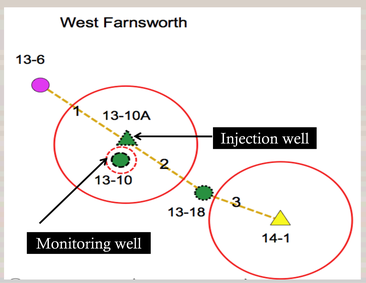
- 3D VSP vibroseis survey- January 2015: 10 active sources with 9 sweeps at each source location that were acquired during a 3D VSP survey in January 2015 with vibe input signal and trigger time recorded as ground truth on two of the array channels. Over 1200 other vibroseis shots with fewer sweeps were also recorded during the survey.
- Mini-vibe survey- August 2015: 16 near-wellbore shots and 1500m walkaway survey with 3 sweeps at 5 different source locations.
- Hammer hits- 2014-2016: wellbore hammer hits

ALGORITHM



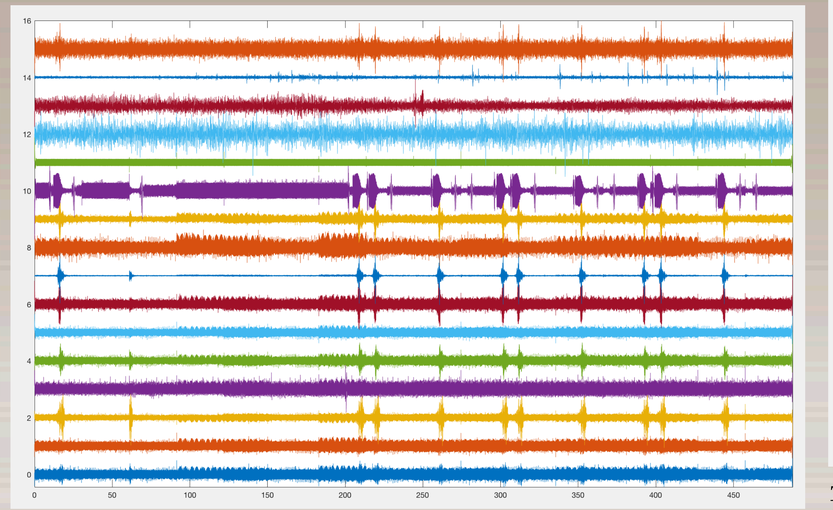
- Automated adaptive sensor tuning (AST) system that identifies near-optimal parameter settings for each sensor using a neuro-dynamic programming (reinforcement learning) paradigm
- Adapts parameter values to the current state of the environment by leveraging cooperation within a neighborhood of sensors
- Key metric that guides the dynamic tuning is consistency of each sensor with its nearest neighbors: parameters are automatically adjusted on a per station basis to be more or less sensitive to produce consistent agreement of detections in its neighborhood
- Adapts in near real-time to changing conditions in an attempt to automatically self-tune a signal detector to identify (detect) only signals from events of interest
- Overall goal is to reduce the number of missed legitimate event detections and the number of false event detections
- Leads to improved event detection and has a significant impact on reducing analyst time and effort

ARRAY LOCATION/GEOMETRY

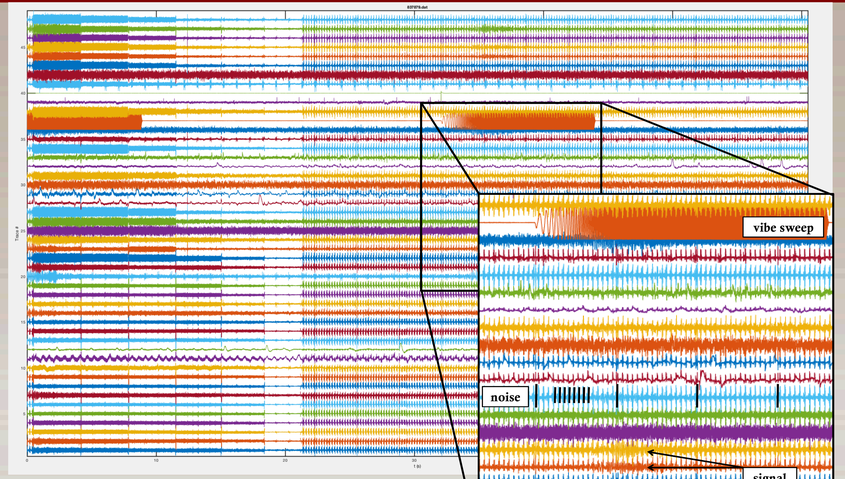


- 3-component dual Geospace OMNI-2400 15Hz geophones with a spacing of 30.5m (100ft)
- 16 levels
- Shallowest at -5385ft/Deepest at -6985ft

EVENT DETECTION



FUTURE WORK



Tuning:

- Attempt to remove triggered false events with zero moveout (presumably electromagnetic noise)
- Remove triggered false events with periodicity matching that of EM noise
- Characterize signal to noise ratio to determine threshold of signal that can be triggered above noise floor

Filtering:

- Determine utility of Kalman and/or autoregressive (AR) filters in removing EM noise
- Identify if bandpass filtering can lower noise floor to increase SN

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