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Towards automatic microseismic cluster localization with DAS

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Currently the capability of detecting earthquakes with decreasing magnitudes demands efficient source localization, especially in seismic monitoring. This work is a step towards automatic high-resolution earthquake localization in a seismic monitoring setup that makes use of Distributed Acoustic Sensing (DAS) as its primary measuring technique. With DAS, the dense spatial sampling of the seismic wavefield leads to an improvement of both event detection and localization of earthquakes. The advantage of DAS is easy and cost-effective deployment compared to traditional seismic instruments (especially in boreholes). However, the single-component nature and the large storage requirements of DAS data demand novel methods for efficient analysis of the recorded events.

We apply a new seismic event location method to DAS data, based on a distance geometry problem in biochemistry for protein structure determination (HADES¹). From the distances between individual earthquakes and a seismic station, the relative distance between the events can be computed. This approach allows us to first determine the relative location of earthquakes within a seismic cluster, and subsequently position the cluster in its correct absolute location. The technique has already been successfully applied for a single traditional seismometer. The densely spaced channels in DAS measurements accommodate accurate relative distance computation, without the ability to constrain the azimuth of the seismic cluster. Therefore, after finding the relative locations within the cluster, the position and orientation of the cluster with respect to the fiber-optic cable is calculated by minimizing the difference between observed and calculated P- and S-wave first arrival times, using a grid search approach (multi-event location). In this way, the absolute locations of all earthquakes present in the cluster are found efficiently. We first test this DAS-adapted method on synthetics, then we will move towards a real data application.

¹ HADES: <https://github.com/wulwife/HADES>