Acoustic localisation in a compressed granular medium

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General Idea

Different acoustic sensors will pick up an acoustic wave at different times. We can then measure the time difference of arrival (TDoA) between pairs of sensors. The pattern of time difference of arrival depends on the acoustic source location.

Experimental Setup

Controlled acoustic waves are emitted at the bottom of the granular pile, and then recorded by an array of 6 piezo-electric sensors. Using 6 sensors, we can measure 3 independent TDoA.

By modeling the acoustic propagation and comparing with observed time differences of arrival, we can look for points with matching TDoA.

Potential sources

\[ H = \{ P \mid |PF_i| - |PF_j| = 2\alpha \} \]

Observed TDoA

Network model with:
- contact points as nodes
- edges between nodes within a grain
- propagation speed along an edge depends on its stress level

Granulars are not continuous (gaps between grains) nor isotopic (chain forces).

Spontaneous emission can also be located as well. While there is no ground truth for comparison, the agreement between the 3 sensor pairs lends weight to the prediction.

On controlled impacts, the predicted source is very close to the ground truth.