**PROBLEM**

We attempt to automatically detect earthquake events recorded on the Stanford Distributed Acoustic Sensing (DAS) Array.

**STANFORD DAS ARRAY (SDASA)**

Distributed acoustic sensing (DAS) is an emerging technology used to record seismic data that employs fiber optic cables as a probing system [1].

Since its installation in 2016, the SDASA has been continuously recording ambient noise, urban noise, and earthquake events beneath Stanford campus [2].

Unlabeled SDASA data

Above: Five minutes of recorded SDASA data

Right: Three examples of labeled SDASA data [3, 4]. (a) A magnitude 3.54 earthquake. (b) 10 min. of urban noise, a recorded quarry blast mixed with urban/ambient noise. (c) A blast event mixed with urban and ambient noise

**USING SINGLE AMPLITUDE AS FEATURE SPACE**

We used a single sample of the amplitude data as our input feature

\[ x^{(i)} = A(ch, t) \in \mathbb{R}, t \in [t_s, t_f], ch \in [ch_0, ch_f], \]

where \( A(ch, t) \) is the amplitude of our data as a function of channel and time. In this case, only one time sample per channel defines our feature space.

**GAUSSIAN NAIVE BAYES**

We first attempted to estimate the distribution of each type of event via Gaussian Naive Bayes where we assume

\[ x \mid y = j \sim N(\mu_j, \sigma_j) \text{ and } y \sim \text{Multinomial}. \]

**SOFTMAX AND SVM**

Using the same feature space, we also performed a softmax regression and support vector machine (SVM) classification. We experimented with both the radial basis function (RBF) and sigmoid kernels defined as

\[ K_{rbf}(x, z) = e^{-\gamma \|x-z\|^2}, \quad K_{sig}(x, z) = \tanh(\gamma x^T z + r). \]

**FUTURE WORK**

In the future, we will change our feature space to consist of overlapping windows along the temporal and channel axes. In this space, the different events present spatial and temporal features that can be recognized by a machine learning algorithm.

Data windows containing:
- (a) ambient noise,
- (b) urban noise,
- (c) an earthquake event

**REFERENCES**


**RESULTS USING SINGLE AMPLITUDE FEATURE**

<table>
<thead>
<tr>
<th>Model</th>
<th>Class</th>
<th>Ambient Noise</th>
<th>Urban Noise</th>
<th>Earthquakes</th>
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<tr>
<td></td>
<td>Precision</td>
<td>Accuracy</td>
<td>Precision</td>
<td>Accuracy</td>
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