Sonos Product Manufacturing Test Optimization

Project Goal

Sonos runs a suite of tests on every speaker during manufacturing to ensure product quality. Our goal is to automate aspects of the testing process classification to improve the testing efficiency.

Improved Working Conditions

Product Quality

Competitive Advantage

Increased Process Efficiency

Our Approach

Our project began with extensive research on audio processing and machine learning techniques. From this work, we selected promising methods to implement.

→ We used data science and signals procesing techniques to transform our data in various ways allowing us to explore the dataset and generate insights.

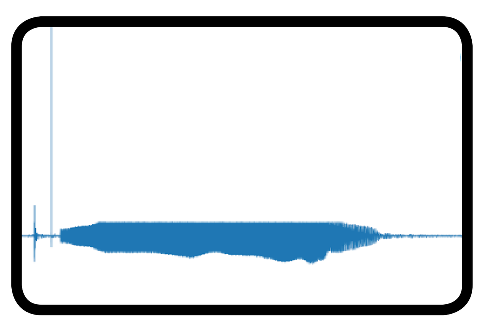
→ After exploring our data set we combined our knowledge of our project space and our specific data set to develop tools for classification and generating insights.

→ Models were constructed and analyzed by varying the parameters of our preprocessing methods and our model architecture.

→ Possible models were benchmarked with a consistent testing infrastructure to allow easy comparison of results, which allowed us to iterate quickly.

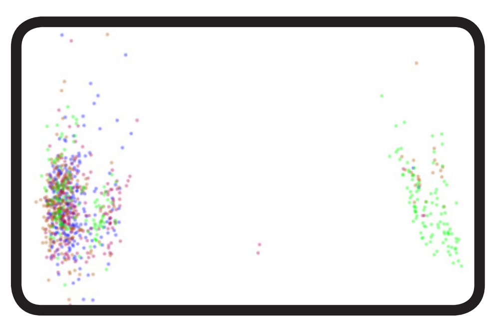
Processing Data

Error Classification



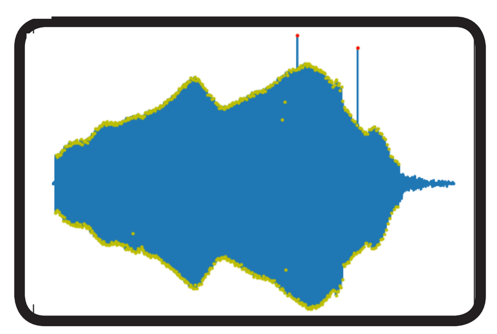
We sorted the error waveforms into ategories based on how they sounded. This process allowed us to look for features that correlated with error types and design filters for each error type seperately.

PCA Clustering



A valuable analysis method, PCA clustering allowed us to investigate the variance between different types of errors. This work validated our error class and transform selection, as it showed seperate clusters for each class.

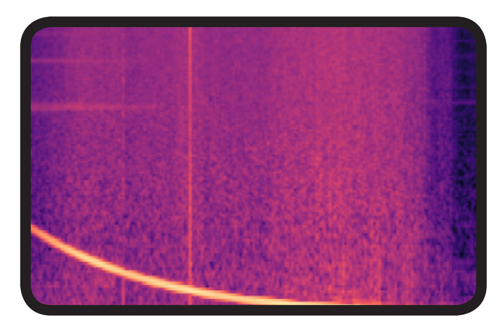
Waveform Analysis



Certain features do appear prominently in the wavefrom but are absent in the spectrogram. We flag waveforms with these features before tranforming the audio signals

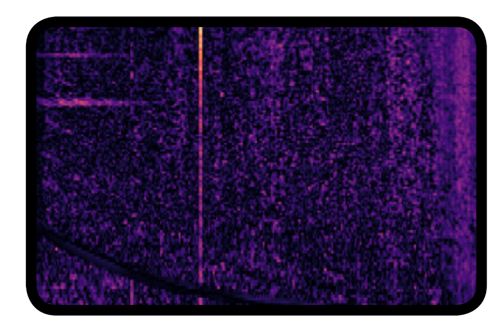
Transforms

Spectrograms



Spectrograms represent the magnitude of each frequency at certain intervals of time. Spectrograms transform audio data into a format easily processed by a convolutional neural net.

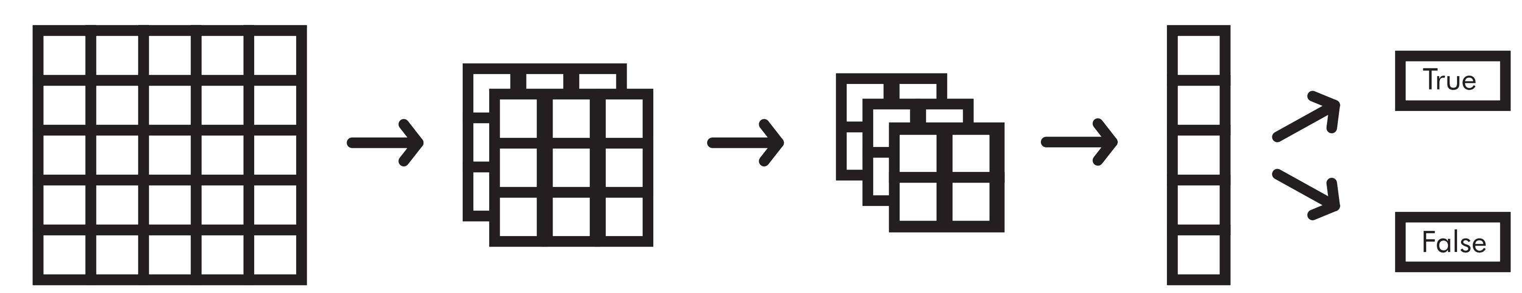
Z-Score



Z-scores highlight features that deviate significantly from the average. High deviation features often indicate errors and help visualize causes of irregular sounds.

Machine Learning

Research supported our preliminary results of convolutional neural nets as the most useful model for our sector of auditory analysis, resulting in us focusing on CNNS. CNNs are most often used for machine learning on visual representations or images but are also traditionally used for machine learning on audio files when they are represented as two dimensional matrices. We used different two dimensional transforms on the waveforms as the input to the CNN. Before using CNNs we tested how our processes and transforms performed on a logistic model as a preliminary step.



Transformed Spectrogram Convolutional Layers Classification

Insights

- Errors should be categorized to enable better classification
- Multiple methods should be used to detect errors including PCA and peak detection
- More errors need to be collected to produce meaningful training on a CNN model
- Mel spectrograms are the most promising type of data transformation

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