Environmental Noise Contamination Detector – Problem Statement

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Overview and Situation

The impact of aircraft noise on a "community" is well-regulated by the Federal Aviation Administration (FAA). Aircraft manufacturers such as Airbus and Boeing must demonstrate adherence to these standards for all new or derivative aircraft models which includes flight testing of prototype aircraft. Community noise flight tests consist of instrumenting one end of a runway of a remote airport with acoustic recording devices and recording the acoustic signatures as the test plane is flown over the instrumentation for many conditions as required by the Federal regulations. To avoid costly and time-consuming repetitions of flight conditions or non-compliance, the surround acoustic environment should cause no undue noise contamination on the acoustic recordings that could cause elevated aircraft noise levels. Sources of contamination can include but are not limited to: bird chirps, wildlife/livestock vocalizations, insect noises, traffic noises, and aircraft noises borne from aircraft besides the target test flight. Current testing procedures use extensive equipment and human labor to detect, assess, and remedy any environmental noise contamination to ensure the recorded acoustic signatures are solely from the test aircraft.

This project is a feasibility study into using automated procedures for detecting and assessing environmental noise contamination. The goal is to monitor, detect, and classify the presence of environmental noise in real-time. The scope of the classification should be sufficient to guide test engineers on the necessary recourse. For example, whether the flight condition need be redone or what type(s) of contaminant noise sources need to be removed from the testing site. Human labor designated for these tasks, while reasonably effective, is taxing and not cost-efficient. Thus, the proposed signal processing and machine learning-based system for this problem.

Target Audience

The target audience of the noise contamination detector is an aircraft manufacturer, the sponsor Boeing Test & Evaluation (BT&E). This project could remove the need for multiple on-site work stations and operators and could lead to significant cost reductions for BT&E. The performance of the system could increase the accuracy and repeatability of the detection, further streamlining regulatory noise testing by BT&E.

Constraints and Requirements

The project, its models, its software code, and data must not limit the commercial use by The Boeing Company. Furthermore, all software code must be executable in MATLAB, the preferred computational platform for the BT&E noise testing division.

Deliverables

1. A trained algorithm, an explanation of its selection, and theoretical background, for detecting audio signals contaminated by environmental noise sources.
2. Measures of the algorithm's performance when deployed in various "environments" – i.e. for a wide spectrum of noisy audio signals and contamination sources.
3. Well-documented process for algorithm retraining and overall project reproducibility.
4. A list of algorithms investigated detailing each one's limitations and advantages.

Information Required from the Sponsor

Labeled example training data (acoustic signals with/without contamination) is required from the project sponsor.

Proposal

The project seeks to research, develop, and implement a signal processing into machine-learning pipeline for automating the detection of environmental noise contamination contained in acoustic measurements. A proposed methodology for achieving such results could be:

1. Feature selection. This portion of the project will require research and implementation of novel audio signal processing techniques to create and select signal features relevant for the classification task. Signal filtering, Fourier analysis, signal-to-noise ratio/signal energy spectrum methods, wavelet transforms, and other time-series transient signal classification methods are potential methods for this purpose.
2. Given a set of features/covariates from (1) above, classification algorithms using the training data. These machine-learning (ML) algorithms will range from basic to complex: i.e. from softmax multi-classification and multi-layer perceptrons, to recurrent neural networks. The algorithms will be considered for their pre-trained execution time as the intended goal is implementation into a real-time monitoring system.
3. Steps (1) and (2) will be continuously re-evaluated according to model performance(s). It is plausible that the features engineered in (1) are not sufficient to result in accurate classification and different signal processing techniques must be researched and deployed. This is also applicable for the ML portion in (2).
4. To assist in the prior steps, the data set from the sponsor may be augmented with other examples of environmental noise that allow for unrestricted commercial use, such as data from the United States National Park Service.
5. Once satisfied with the performance of the pipeline, robust documentation to retrain the algorithm(s) and reproduce and/or adapt our project for BT&E will be generated.