Signal Processing in Ultrasonic Leakage Detection for Inspection of Vacuum Tubes

Short Description

Vacuum Transportation relies on a constant low pressure level inside the vacuum tube for high-speed and safe travel of the vehicles.

The test track AlphaTube, built by EuroTube Foundation, figures a compound concrete shell with polymer sealant layers featuring a light-weight, low-cost and scalable solution. To maintain a nominal pressure of 1 mbar vacuum pumps continuously compensate for the pressure increase due to air inflow at junctions and permeation through the shell.

Ruptures (shrinkage, cracking, etc.) or breach in the shell cause ambient air leaking into the vacuum volume compromising safety. To restore an air-tight system the leakage entry point has to be detected and sealed, which leads to costly operation down-times.

Some testing with ultrasonic microphones for leak detection has already been conducted. A simple prototype with a 6-microphone (figure 1) array has been built.

This thesis shall investigate signal processing methods (machine learning) for detection and localization of the sound generated by abnormal inflow into the tubes. The pyAudioAnalysis library could be used for feature extraction. There is a lot of literature on this topic. For example this paper on deep learning for audio signal processing.

Type	Semester project or MSc thesis
Partner	EuroTube Foundation
Start date	14.09.2020
End date (planned)	tbd
Student(s)	tbd
Internal supervisor	Fabio Dubois, fabio.dubois@eurotube.org
External supervisor	Michele Magno, michele.magno@pbl.ee.ethz.ch

Work packages
- Literature review of related work
- Compilation of requirements list
- Study of signal analysis methods
- Data collection for model training
- Implementing signal analysis and triangulation
- Testing and performance evaluation on demo inspection case[1]
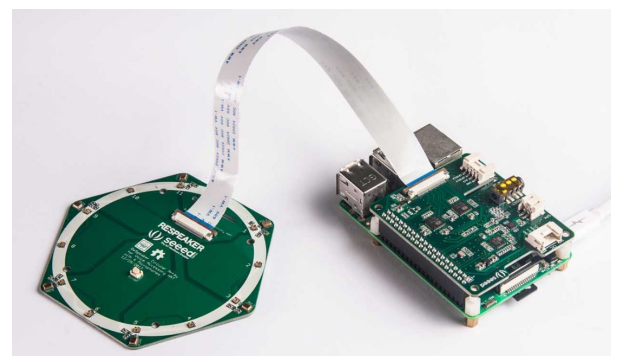- Bonus: PCB design for integration of mic array onto custom interfacing PCB

Figure 1: Current setup

Requirements
- High motivation and interest in the topic
- Able to work independently and be creative
- Methodological and goal-oriented working behavior
- Good theoretical understanding of compressible fluid dynamics
- Experience with signal analysis and machine learning
- Experience with mechatronic systems and embedded electronics and software
- Knowledge about vacuum transport technologies is beneficial

Application

Please email your CV and transcript to michele.magno@pbl.ee.ethz.ch.

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[1] The current setup consists of a 6 mic array and a raspberry Pi version 4 to be tested on concrete samples under vacuum (~100 mbar).