Technical Report for Sound Leakage Visualization

A Project for Acoustics and Air Testing Laboratory Co. Ltd.
Empowered by Hanlun Artificial Intelligence Limited
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Table of Contents

1. Project Objective

1.1 Motivation

This project presents a commercial attempt to utilize existing measurement methodology by advanced data analytics capability. Industrial packages for signal post-processing had been used to empower a conventional signal receiver to achieve magnitudes of enhancement in signal resolution. The high resolution output can be visualized for better explainability to preach a larger consumer base.

1.2 Signal Processing and Visualization

Specifically, the conventional signal receiver is a Class I sound level meter; and the measurement methodology is a regular scanning of a sound level meter on a wall (See Figure 1.1), with noise synthesized from the other side, to generate a grid of sound leakage measurements in log files and wav files (See Figure 1.2). The solution presented an analytics and visualization software with fundamental functionality following the industrial standard to analyze various ranges of frequencies from 31.5 Hz to 8000 Hz. For each range, the grid data are post-processed to be orders of magnitude higher resolution, so that a visualization in the form of heatmap is made available to the Client to answer industry problems. With these heatmaps, the Client may now easily show to industrial customers the result of sound leakage measurement and analysis.

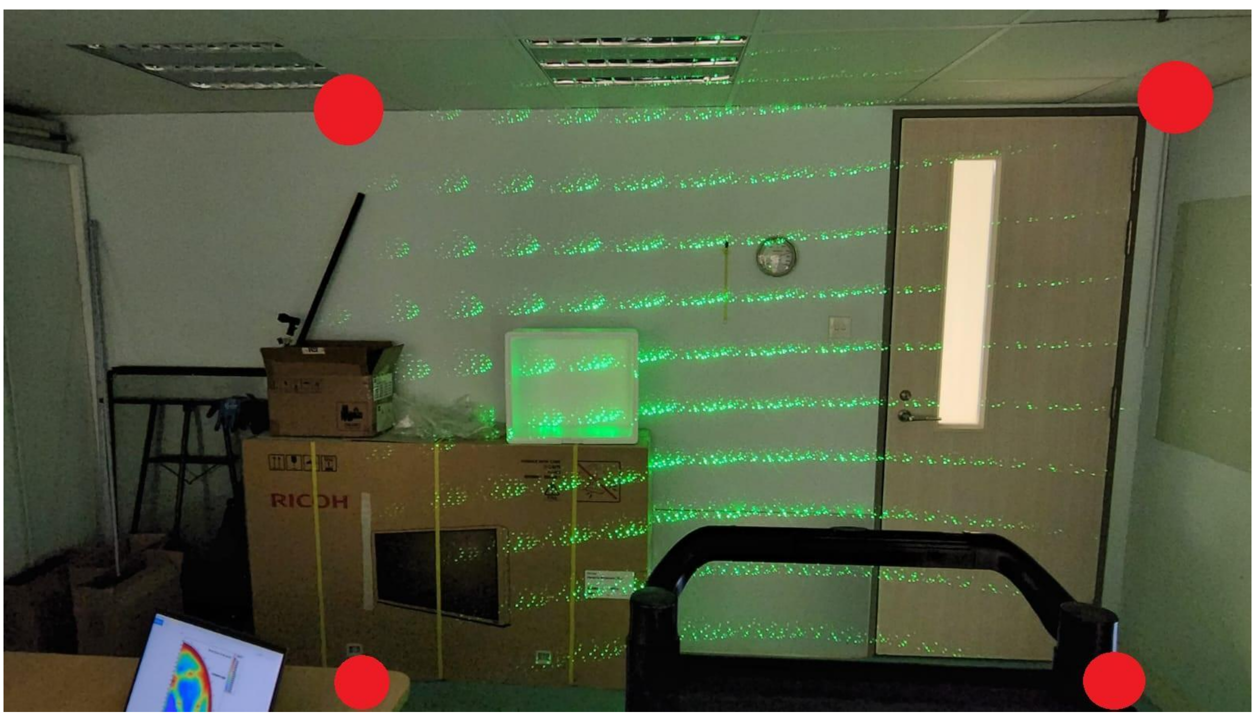


Figure 1.1 A wall with four red circles indicating the corners of the region of sweeping

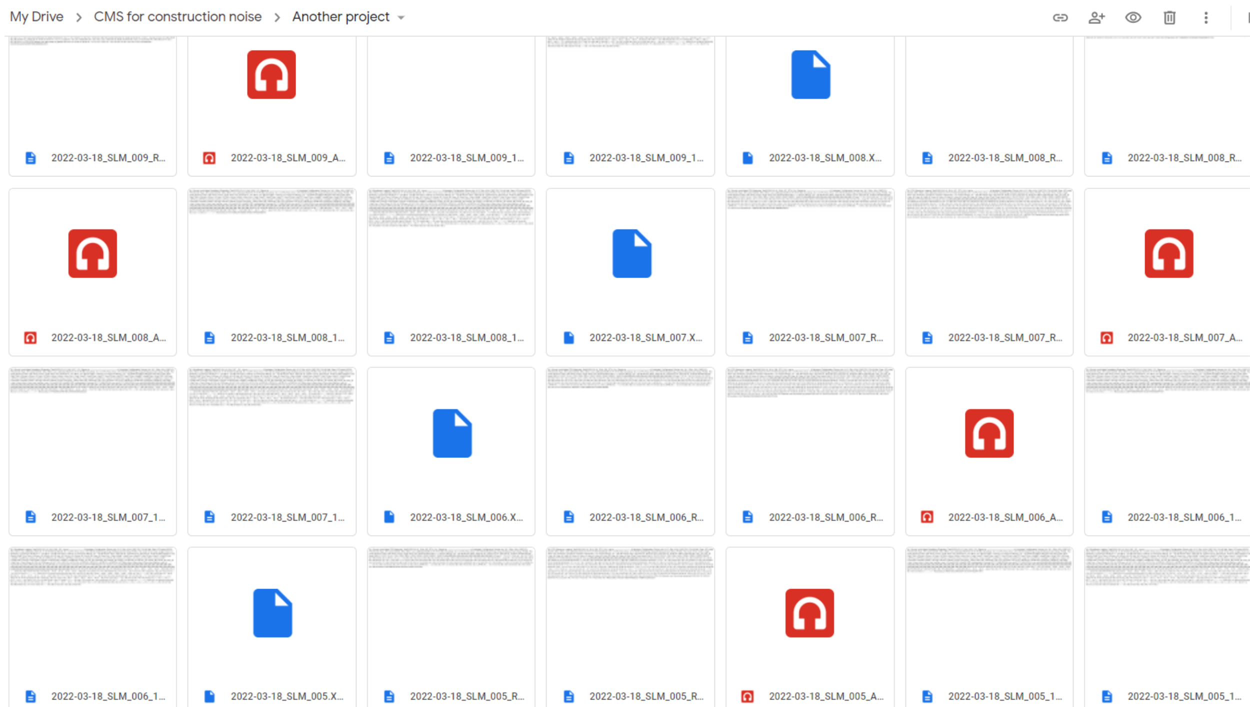


Figure 1.2 To construct a tailor-made data analytics pipeline, naming of wav files and conversion of log files are specified in the input folder

2. Solution Delivery

2.1 Calibration

Practically, both wav files and log files are needed as input to the software solution. *.wav files contain richer raw measurement data that reflect reality in more detail. But these raw data are in the form of relative measurements and need those log files (with some absolute amplitude calibration information) to perform calibrations.

2.2 Sound Pressure Level Sampling

Simple sampling is done in a grid with around 10 rows of data scanning from top to bottom. In each row, the default setting is to scan uniformly in around 10-20 seconds from left to right, alternating the direction in consecutive rows is also possible in customization.

2.3 Super-Resolution

Following industrial standards to transform the data in ranges of frequency from 31.5 Hz to 8000 Hz, the software further performs super-resolution as a post-processing procedure. For such purposes, both methods of FFT resampling and cubic spline interpolation are investigated. Before the kick-off of this project, the grid resolution from log files was 10 by 10, now we could obtain a grid resolution of 2500 by 2500.

2.4 Visualization as heatmap

For higher explainability, the results of post-processed high resolution sound pressure levels are visualized as heatmaps. The overall result is given in the A-weighted Leq sound level as in Figure 2.1. Different frequencies might have different leakage problems, so we also plot results for specific frequency bands in Table 2.1.

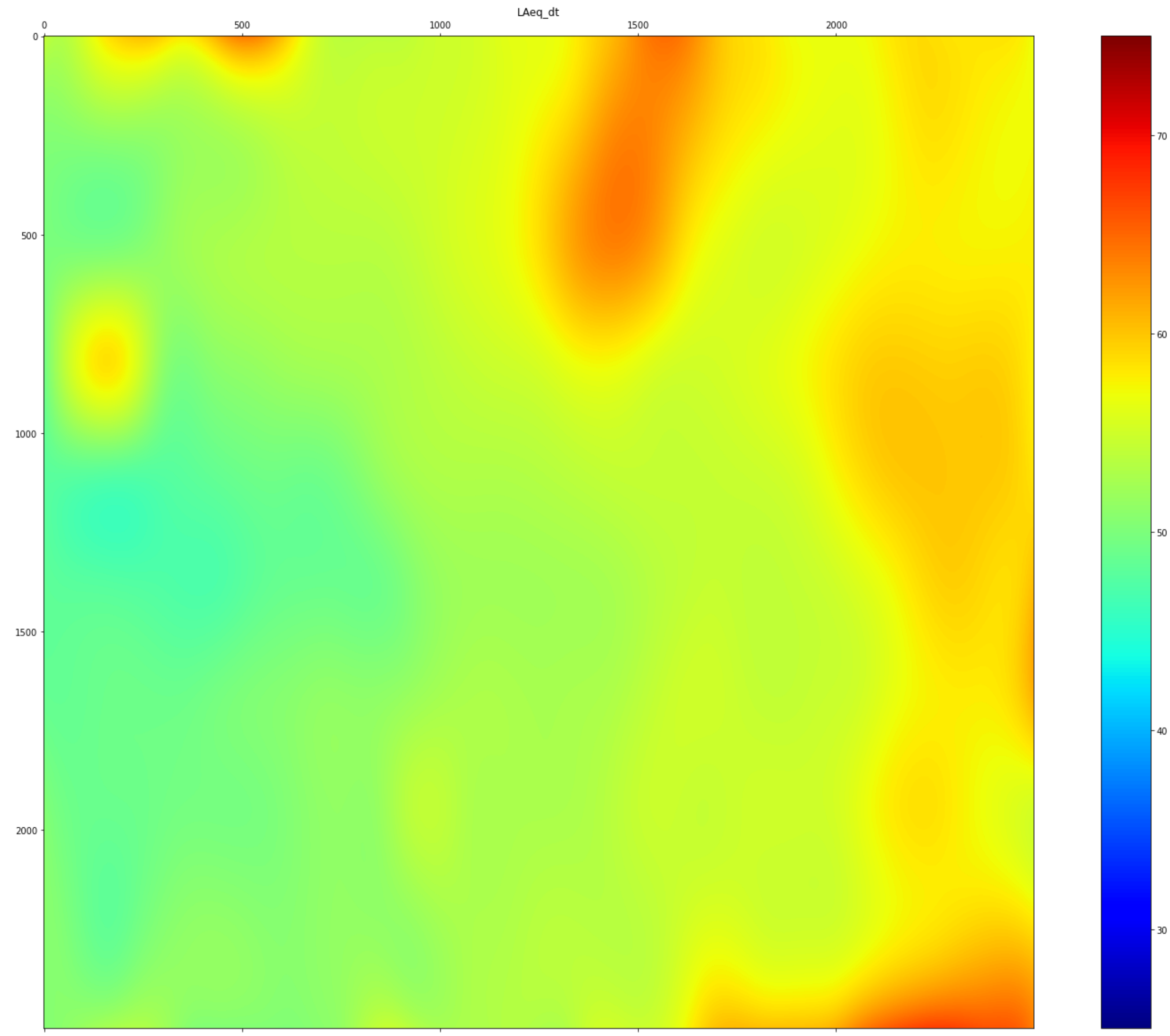


Figure 2.1 Overall sound leakage map, sound pressure level in dB(A)

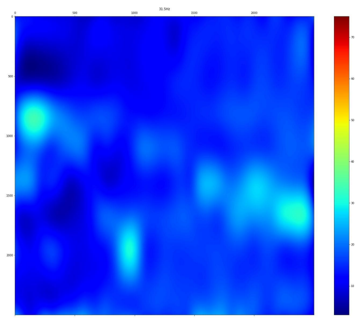
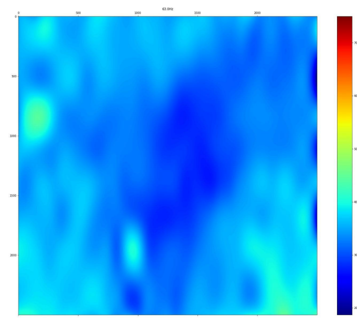
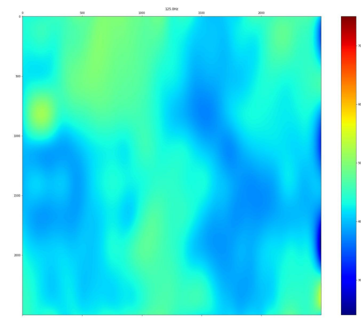
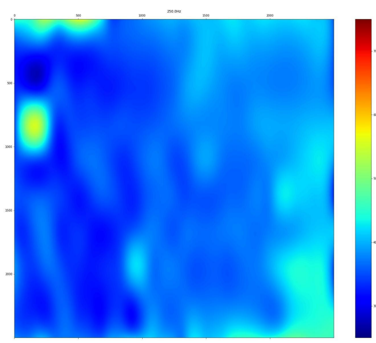
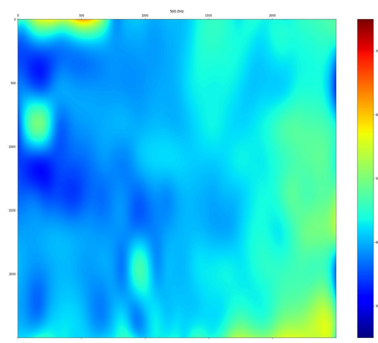
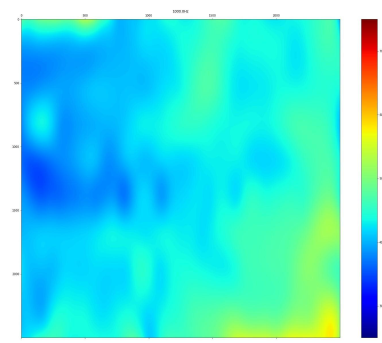
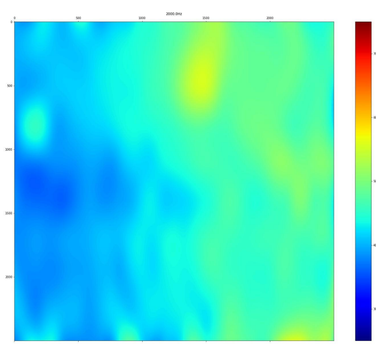
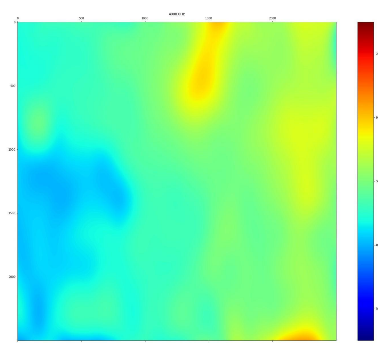
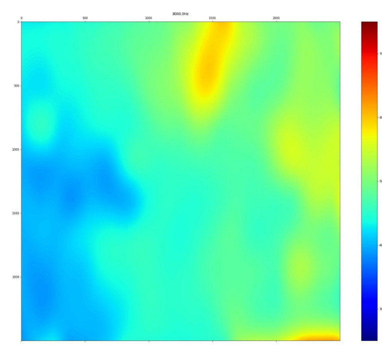
 31.5 Hz	 63.0 Hz	 125.0 Hz
 250.0 Hz	 500.0 Hz	 1000.0 Hz
 2000.0 Hz	 4000.0 Hz	 8000.0 Hz

Table 2.1 Sound leakage map for different frequency bands, sound pressure level in dB

2.5 Image Processing

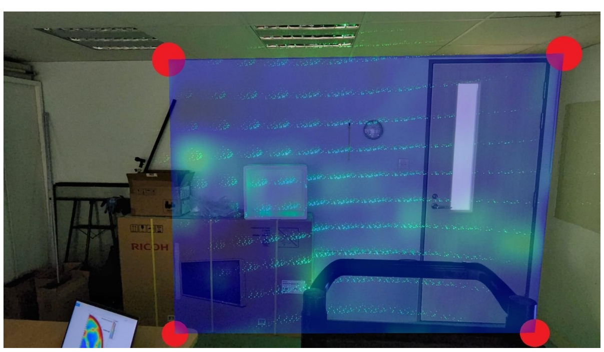
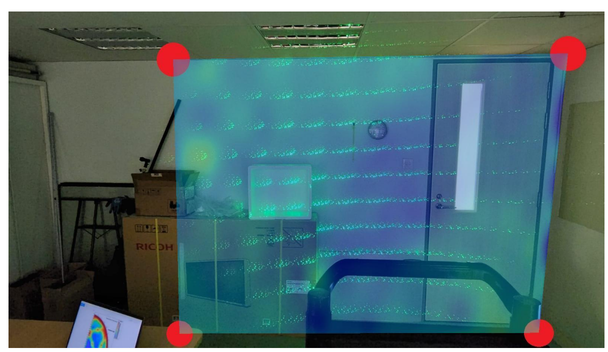
Other than the sampling record, the software also takes as input an image with scanning area marked. Some image processing is done to detect the marked region.

2.6 Perspective Transform and Overlay

Lastly, the software performs standard perspective transformation to project and overlay heatmap into the scanned image. The overall result is shown in Figure 2.2.

Figure 2.2 Overall sound leakage map projected and overlaid to input image

Results by underlying frequency are shown in Table 2.2.

 31.5 Hz	 63.0 Hz

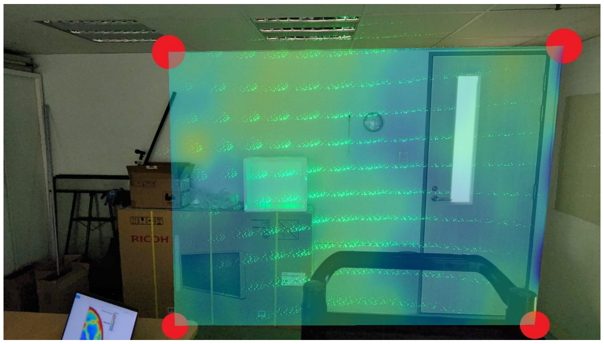
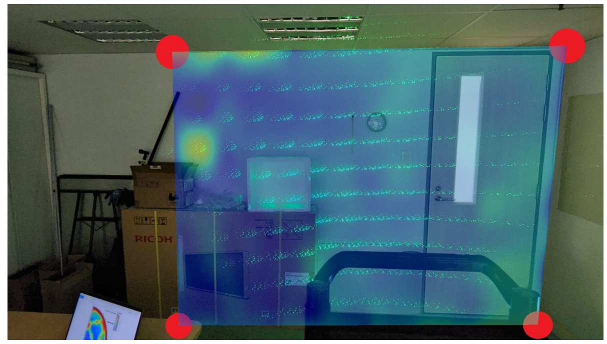
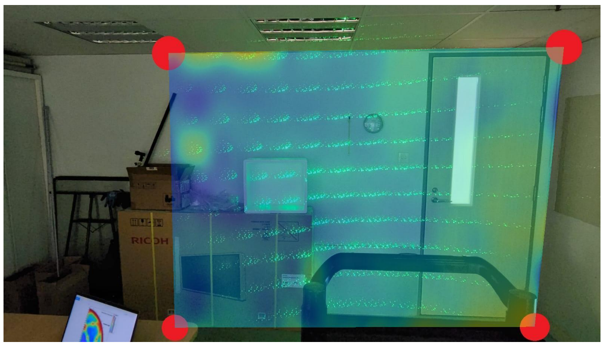
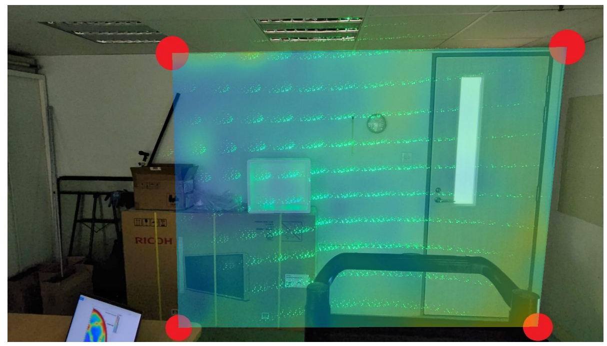
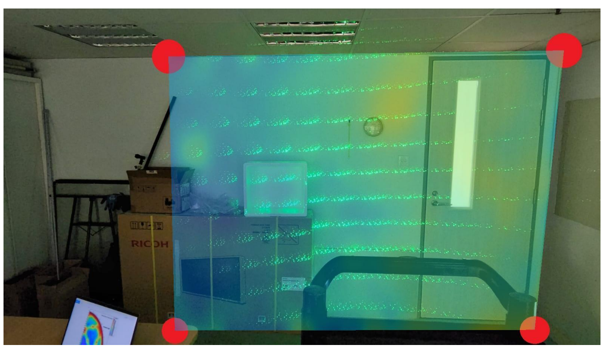
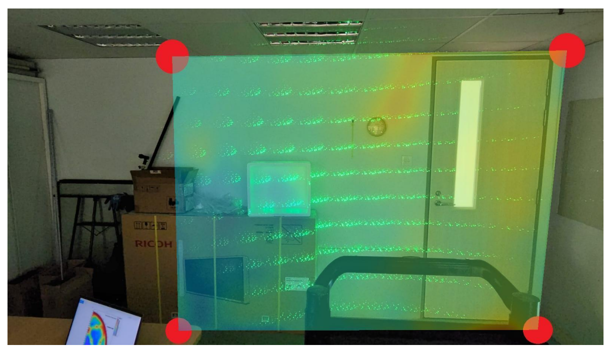
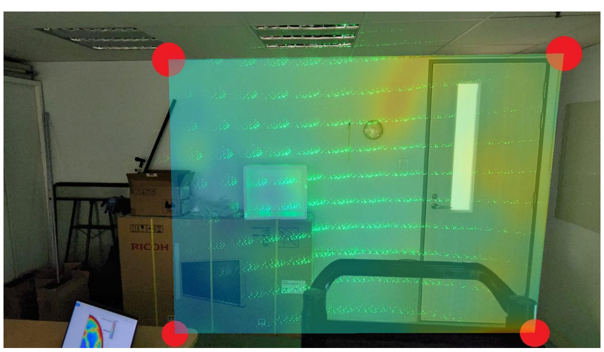
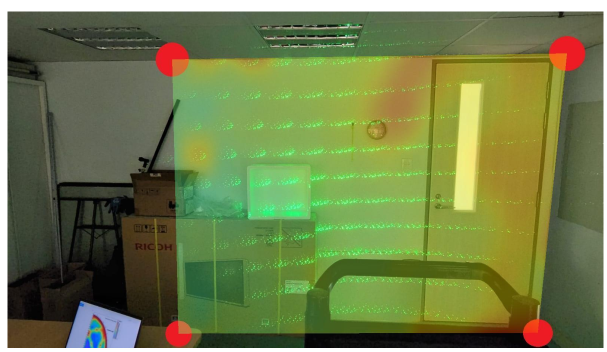
 125.0 Hz	 250.0 Hz
 500.0 Hz	 1000.0 Hz
 2000.0 Hz	 4000.0 Hz
 8000.0 Hz	 Overall

Table 2.2 Specific frequencies sound leakage map projected and overlaid to input image

3. Remarks: Future Work Beyond Project Scope

3.1 Discretization and Contours in Vector Format

Beyond project scope, we may further discretize the sound pressure level to plot a heatmap in the form of filled contours. The overall result is plotted in Figure 3.1 as an example. Note that such a representation is in vector format and it could be displayed clearly in monitors of arbitrarily high resolution.

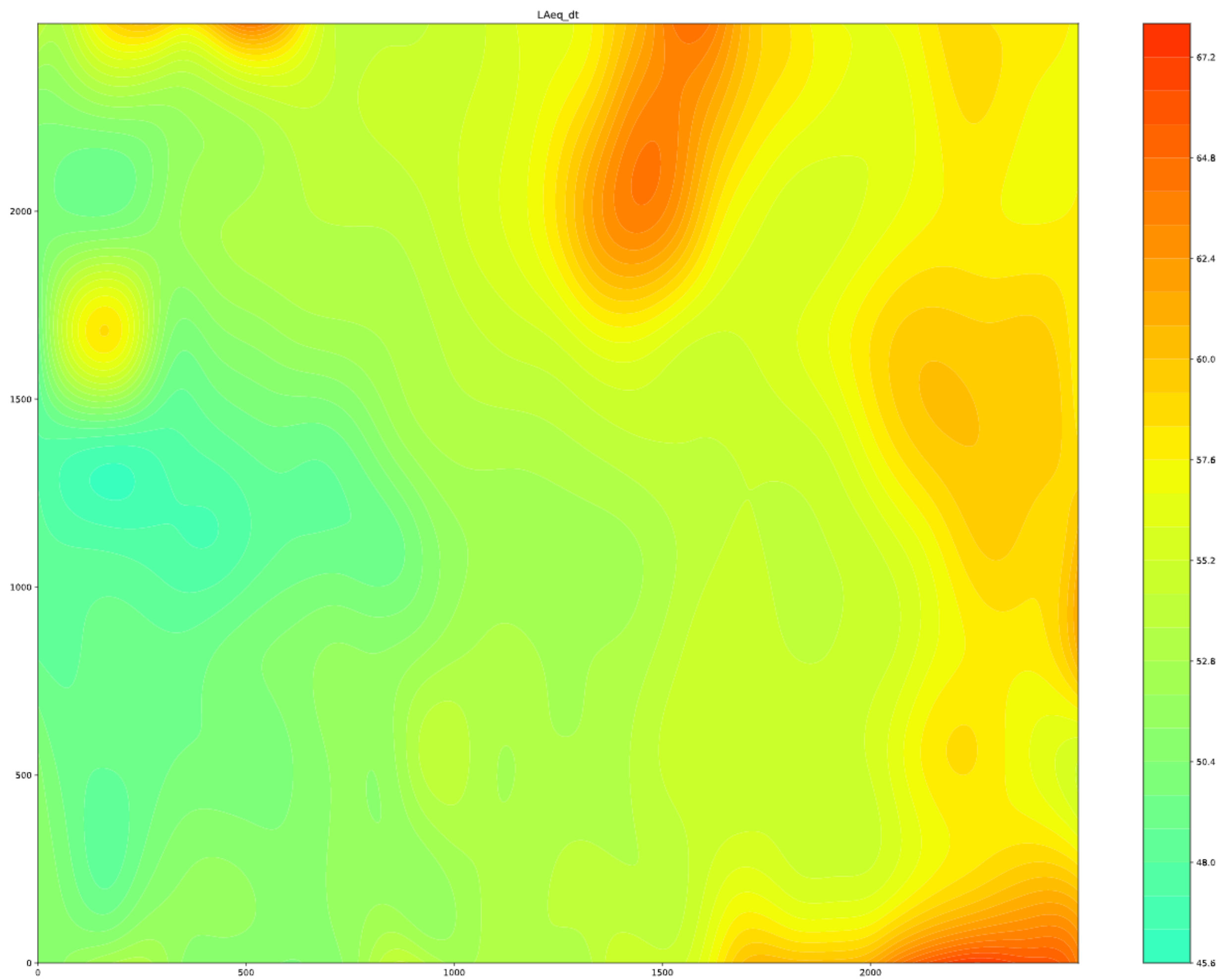


Figure 3.1 Overall discretized sound leakage map represented in contours (vector format)

3.2 3D Landscape

Another useful representation of recorded signal amplitude in a grid is a 3D Landscape map. Similar to contours, it is not required in the project, but it can be derived consequently after we perform the analysis and super-resolution of signals in Section 2. A demonstration can be seen in Figure 3.2.

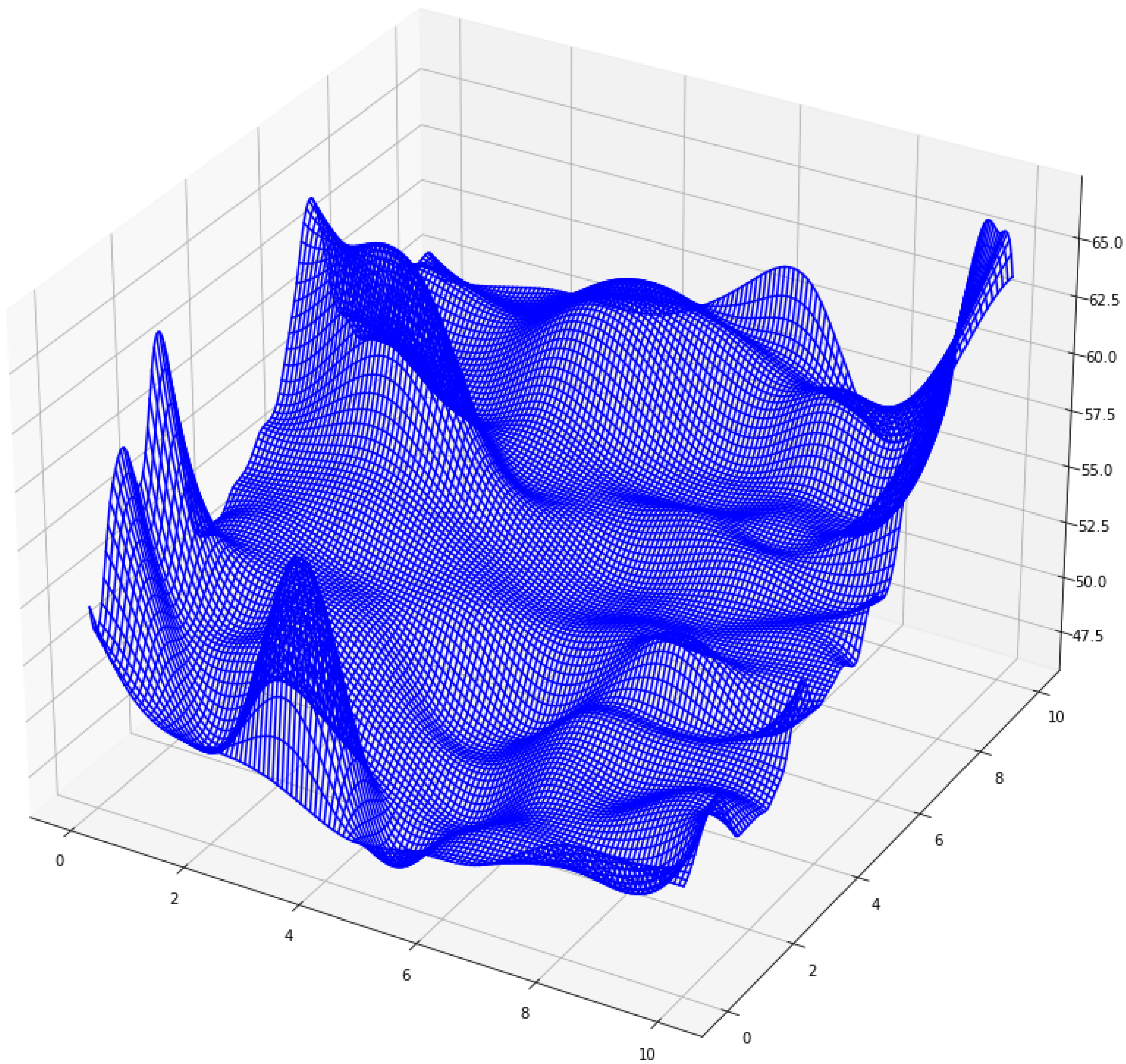


Figure 3.2 Sample signal amplitude map in 3D landscape

3.3 Other Signals

Signal sources had been the first productions of a few multi-national tech companies, including Hewlett-Packard who started their journey with a series of spectrum analyzers. Many sophisticated measurement devices for signal recording had been developed in past years in acoustics, mechanical and vibration measurements domains. Hopefully our project would mark a new beginning of using powerful post-processing capabilities to better utilize those existing well-established measurement devices.