Detailed Description of the recording of a spectrogram

The recording of a spectrogram can be described in detail as follows: The time-domain signal is firstly resampled towards an angular-domain signal. As the signal is equidistant in angle being subsequently Fourier-transformation it results an order spectrum. The emerging ratios between measured speed and frequencies (resulting in a constant order) can be attributed to different components based on their geometry and assembly. Hence, the vibration amplitudes are not plotted against frequency [Hz] but against orders (Hz/rpm).

The complete measurement consists of an acceleration of the engine up to a maximum speed. For a fixed set of rpm-values, a spectrum is calculated and assembled to a spectrogram as shown in Figure 1. Its x-axis shows the orders and the y-axis sorts the spectra by their speed. Consistent excitations of constant orders result in vertical lines, while resonances (being constant in frequency) show as approximate 1/x-trends. The volume of the structure-borne noise in each order can be determined in a color scale, where in the example figure brighter colors represent particularly loud orders. In the context of vibration measurements in serial manufacturing, regions of loud frequencies tend to be a good indicator for an error within a measured engine. The general volume of an engine rises with its speed. Therefore, a direct comparison between different speeds is more meaningful if the residual value is calculated for each point in the spectrogram. The residual value consists of a deviation from the measured value to the mean value μ of an ensemble of engines, divided by the corresponding standard deviation σ. This sets each deviation into the correct context as a deviation of 3[dB] occurring in regions with low scatter (e.g. σ = 1 [dB]) are weighted more strongly. This indicates a severe deviation from the normal state of the engine. In contrast the same deviation of 3[dB] may be part of the normal scatter in other regions with (e.g. σ = 5 [dB]). In the latter case the deviation is seen as normal. Consequently, the view of residual values directly promotes significant and suppresses non-significant deviations.

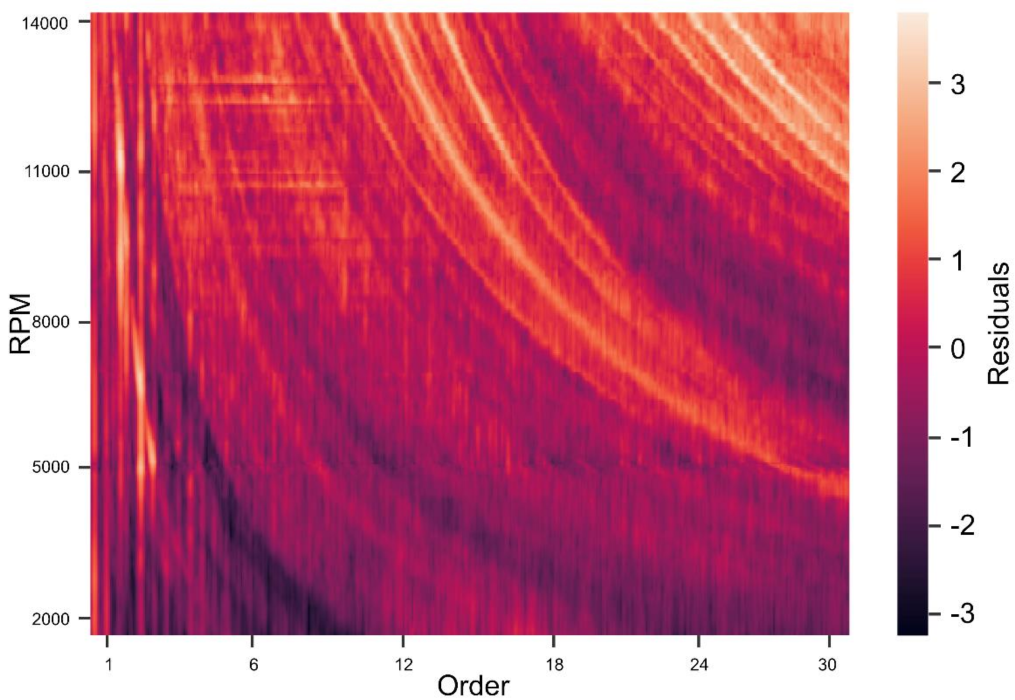

Figure 1: Spectrogram of structure-borne noise for an engine, where rpm is shown on the y- and orders on the x-axis. The color indicates the volume of the measurement compared to the mean serial distribution of all engines.

Interview Guideline - Design Study IRVINE

Participant information:

Name:

Age:

Department:

Professional background:

Years of experience in the problem domain:

Duration of the interview:

Introduction:

Do you agree to record the audio of this interview?

We start with a small recap on the Hypermatrix from our initial kick-off meeting. Next, we continue with a system introduction, explaining every view to you in detail. After that, we will give you specific task, which you need to execute. Finally, we will ask you some open-ended questions about IRVINES system components. For a general system evaluation, we will do a questionnaire (SUS Scale) after the interview is done. If you have any questions, feel free to interrupt anytime!

Task:
Please find error prone engines and provide labels and annotations for each engine.

Open ended Questions:

1) Please describe in our own words how you did select an engine with IRVINE.
2) How could you determine that exactly this engine was relevant for an in-depth analysis?
    a. How did the cluster view help you in selecting a specific engine?
    b. How did the table view help you in selecting a specific engine?
3) After you selected an engine; Please describe in your own words how you analyzed the selected engine.
4) How could you determine, which sub-components (A-Bearing/B-Bearing…) were relevant?
    a. How did the Hypermatrix view help you with your analysis?
    b. How did the spectrogram view help you with your analysis?
    c. How did the line chart help you with your analysis?
    d. How did the scatterplot help you with your analysis?
    e. How did the bar chart help you with your analysis?
5) Did you use previous domain knowledge to guide your analysis (by clicking on the suggest label button, or the label bar chart view)
    a. How did this domain knowledge help you with your analysis?
6) Were you able to solve the given task with IRVINE?
7) What were your original expectations of IRVINE?
8) Is there anything you would like to change in the system, which could facilitate your analysis?

SUS Scale

1. I think that I would like to use this system frequently

1. Strongly disagree	2	3	4	5. Strongly agree

2. I found the system unnecessarily complex.

1. Strongly disagree	2	3	4	5. Strongly agree

3. I thought the system was easy to use.

1. Strongly disagree	2	3	4	5. Strongly agree

4. I think that I would need the support of a technical person to be able to use this system.

1. Strongly disagree	2	3	4	5. Strongly agree

5. I found the various functions in this system were well integrated.

1. Strongly disagree	2	3	4	5. Strongly agree

6. I thought there was too much inconsistency in this system.

1. Strongly disagree	2	3	4	5. Strongly agree

7. I would imagine that most people would learn to use this system very quickly.

1. Strongly disagree	2	3	4	5. Strongly agree

8. I found the system very cumbersome to use.

1. Strongly disagree	2	3	4	5. Strongly agree

9. I felt very confident using the system.

1. Strongly disagree	2	3	4	5. Strongly agree

10. I needed to learn a lot of things before I could get going with this system.

1. Strongly disagree	2	3	4	5. Strongly agree