

Development of an application for analyzing vehicle sounds

Satoshi SAITOH* Tsuyoshi ENDO*

Summary

Analyses of worrisome sounds occurring in vehicles are not widely conducted by the general public because they require specialized equipment and software. Accordingly, it was hypothesized that using a smartphone would enable anyone to analyze sound data easily. An application has been developed that can automatically analyze sound data recorded in the videos which contains the dashboard gauges movement obtained with a smartphone. An application has been developed that can automatically analyze sound data and dashboard instrument videos obtained with a smartphone. This article describes the activities undertaken to develop this application.

1. Introduction

When drivers hear a worrisome sound in their vehicles while driving, they may take their vehicles to the nearest car dealer because they want to get advice or have some improvement made. A technician at the dealer where the vehicle is brought determines the source of the indicated sound and implements a measure to improve the problem if the vehicle owner so desires. However, there are often cases where it is very hard to determine the sound source because sound analysis involves an extremely high degree of difficulty.

In such cases, the dealer technician may use a voice recorder or some similar device to record the sound in question and then sends the sound data to the vehicle manufacturer's service center to get advice.

An engineer at the service center who receives the inquiry analyzes the sound data in place of the dealer technician. If the engineer has a clue about the sound source, that information is conveyed back to the dealer technician. However, like the dealer technician, there are cases when service center engineers also have a hard time determining the sound source based solely on the sound data received.

In order to resolve such problems, we have developed an application that makes it easy to determine sound sources even for people who are not sound specialists.

This article describes the development activities that were undertaken.

2. Difficulty of sound analysis

What is the inherent difficulty in sound analysis? The difficulty lies in representing sound visually. The conventional approach to visualizing sound is to first conduct a fast Fourier transform (FFT) analysis of the sound data. After the FFT analysis, a spectrogram is then drawn based on the data obtained (Fig. 1).

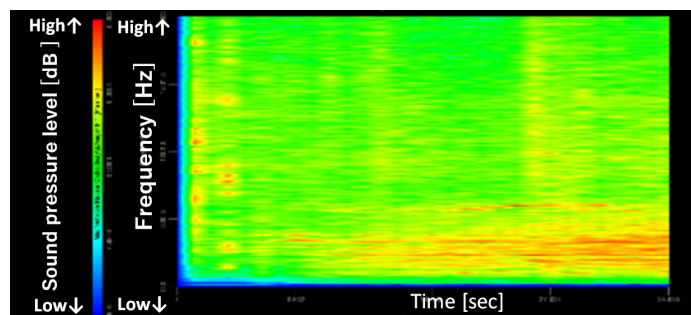


Fig. 1 Spectrogram analysis

The horizontal axis of a spectrogram represents time, the vertical axis shows the frequency, and the shades of color express sound pressure levels. Drawing a spectrogram provides the following benefits.

- The frequency of the indicated sound can be confirmed.
- The change in the frequency with time can be confirmed.

* Quality Assurance Department, JATCO Engineering Ltd

In addition, if engine speed data and vehicle speed data have been recorded simultaneously with the sound data, a rotational order ratio analysis can also be performed.

As mentioned here, many benefits can be obtained by conducting an FFT analysis and drawing a spectrogram. However, performing such analyses generally requires specialized devices, software and knowledge of sound, and for that reason they are not widely conducted at present.

3. Determinable range by visualization

Let us assume that a service center received over 100 inquiries about sounds during the past one year and that the sounds recorded at car dealers were visualized at the center. An investigation was made of the extent to which sound sources could be determined at the service center.

As the results in Fig. 2 show, it was estimated that sound sources could be determined based on only a spectrogram in approximately 21% of the total number of cases. If engine speed data and vehicle speed data can be viewed simultaneously with the spectrogram, the percentage of cases in which it is estimated sound sources can be determined increases further by approximately 37%. Adding the two percentages together, the results reveal that sound sources are determinable at service centers in approximately 58% of the cases.

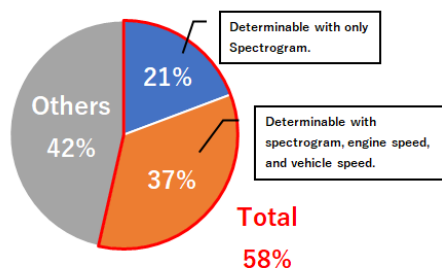


Fig. 2 Breakdown of sound sources determinable by visualization

Development activities aimed at the two objectives below were carried out for the purpose of enabling sound source determination at service centers 58% of the time.

- Establishment of a method for obtaining engine speed data, vehicle speed data and sound data simultaneously

- Development of an application enabling simple visualization of sound data

4. Investigation of a recording tool

4.1 Definition of the requirements for a data recorder

The following requirements were defined for a data recorder in order to achieve the objective of establishing a method for simultaneously obtaining engine speed data, vehicle speed data and sound data.

- Inexpensive
- Capable of simultaneously obtaining engine speed data, vehicle speed data and sound data
- Capable of recording sounds in a frequency range of 300 Hz to 8 kHz, which is required for measurement of vehicle noise and vibration

4.2 Selection of a recording tool

It was decided to use a smartphone as the recording tool for satisfying the requirements listed above. A major advantage of using a smartphone is that it eliminates the need to buy a new device because smartphones have already penetrated society widely in general. Accordingly, it would substantially reduce the cost of purchasing a recording tool.

In addition, simultaneous recording of engine speed data, vehicle speed data and sound data can be accomplished by taking videos of the dashboard instruments within the photographable range of a smartphone camera (Fig. 3). This is another major reason why a smartphone was selected as the recording tool.



Fig. 3 Simultaneous recording of engine speed, vehicle speed and sound data

With regard to recording capability, the microphone built into smartphones usually has a recording frequency range of approximately 100 Hz to 10 kHz. This is narrower than the frequency range of the microphones used by vehicle manufacturers and others, which is typically 20 Hz to 20 kHz. However, this frequency range of approximately 100 Hz to 10 kHz is equal to the level of the voice recorders used by car dealer technicians. Moreover, because the frequency bandwidth required for measuring vehicle noise and vibration is around 300 Hz to 8 kHz, it was judged that smartphones could be used as the recording tool without any problem.

5. Application development

5.1 Definition of application requirements

The following requirements were defined for the application in order to achieve the objective of developing an application enabling simple visualization of sound data.

- Easy to operate
- Allowing simultaneous viewing of a spectrogram and a vehicle instrument video
- Linking of the spectrogram cursor and the video playing time
- Enabling a comparison of spectrograms of recorded sound data and sample sound data
- Enabling a comparison of auditory perceptions of recorded data and sample sounds

The specifications were determined based on the requirements listed above, and the application was then developed.

5.2 Development of the application

A desktop application that runs on a PC was adopted in consideration of screen visibility and ease of operation (Fig. 4). In addition, usability was improved by adopting specifications that allow all operations to be performed automatically, from FFT analysis to drawing of a spectrogram by just dragging and dropping photographed videos onto the application.

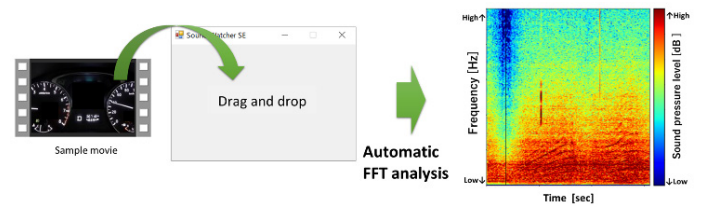


Fig. 4 Application for automatic FFT analysis

The design adopted for the user interface positions the spectrogram on the left side of the screen and a video taken with a smartphone on the right side. This allows an analysis to be conducted while constantly comparing vehicle behavior and the spectrogram (Fig. 5).

Moreover, the cursor is positioned such that it moves over the spectrogram in concert with the playing time of a video, making it easy to confirm the moment when a sound occurs.

Thanks to these measures, the frequency of the sound of interest can easily be confirmed based on the shades of color and the time when the sound occurs.

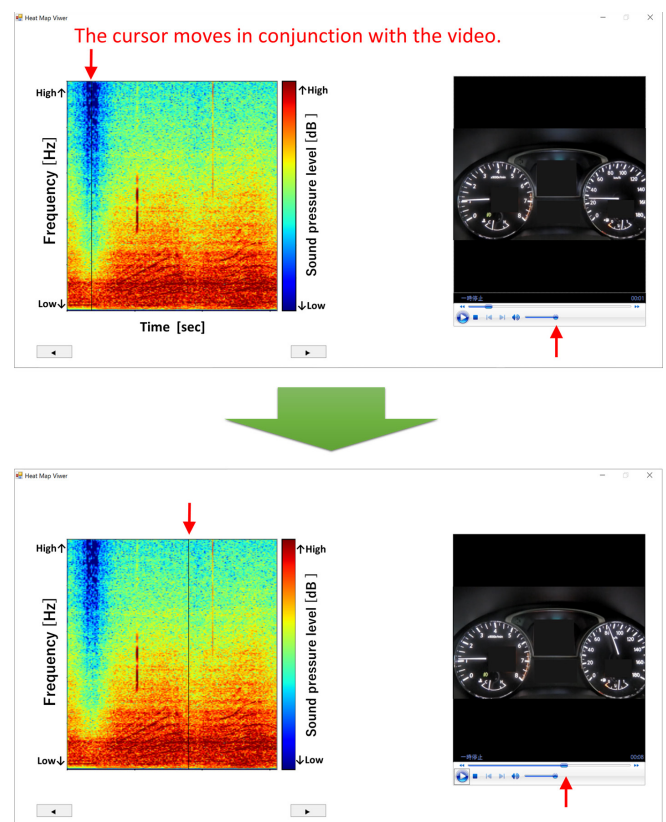


Fig. 5 Movement of spectrogram cursor linked to video of vehicle instruments

The application also incorporates sample images of past data appended with additional information such as sound sources, frequencies, sound magnitude, onomatopoeia, and characteristic visual aspects of spectrograms, among other things.

This makes it easier to narrow down sound sources by comparing the spectrogram of the sound recorded at a car dealer with the sample images already incorporated in the application in advance (Fig. 6).

Comparing frequencies and other information in addition to characteristic visual aspects of spectrograms enables judgment of sound sources with even higher accuracy.

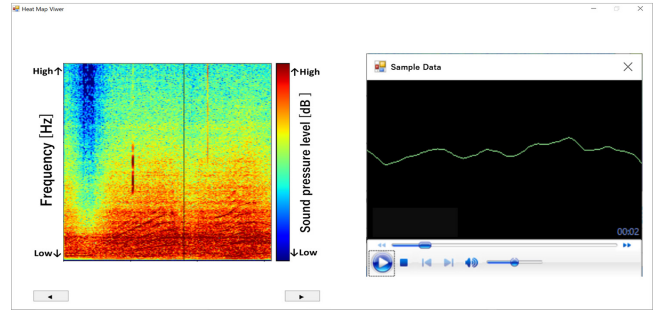
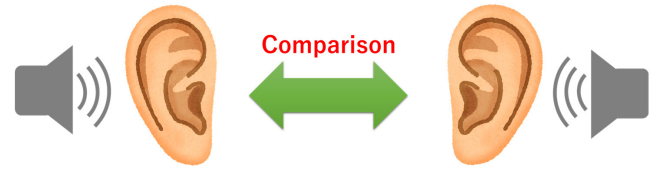


Fig. 7 Comparison of recorded sound and sample sound

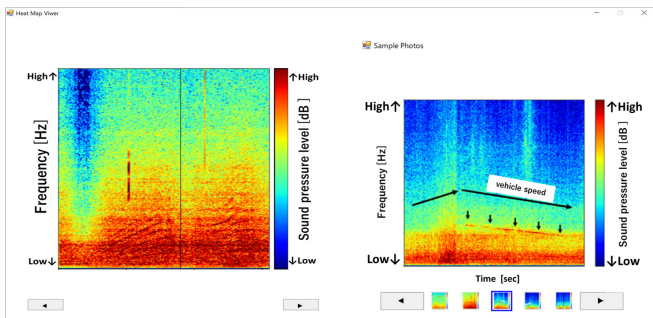


Fig. 6 Comparison of recorded data and previous data

Because sample sounds can be heard in addition to seeing sample images, auditory judgments can also be added to visual judgments. This is another factor that improves judgment accuracy (Fig. 7).

6. Conclusion

Conventional FFT analysis has required specialized equipment and software. However, the newly developed application uses a smartphone as the recording tool and automatically analyzes videos taken with the smartphone camera. Consequently, this application enables determination of over 50% of the sound sources which could not be identified heretofore at vehicle service centers. Going forward, we will continue our development activities with the aim of developing a tool that will automate even the final judgment of sound sources.

■ Authors ■



Satoshi SAITOH



Tsuyoshi ENDO