Distortion-based Visualization for Long-term Continuous Acoustic Monitoring

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Abstract

Visualizing long-term acoustic data has been an important subject in the field of equipment surveillance and equipment diagnosis. This paper proposes a distortion-based visualization method of long-term acoustic data. We applied the method to 1 hour observation data of electric discharge sound, and our method could visualize the sound data more intelligibly as compared with conventional methods.

CR Categories: H.5.2 [User Interfaces]: Auditory (non-speech) feedback—Graphical user interfaces (GUI); H.5.5 [Sound and Music Computing]: Signal analysis, synthesis, and processing—;

Keywords: Acoustic visualization, distortion, monitoring

1 Introduction

Long-term acoustic data of equipments (ex. insulator, transformer or turbine) has been archived and analyzed in many equipment industries to observe the equipments and to reveal degradation mechanism of them. In the early phase of the analysis, detecting changing points in long-term data is important. Changing points, for example, express the starting points of degradation of insulation ability. Listening capability of professional observer is utilized to distinguish the changing points. However, listening check of long-term sound by human is a hard task and long experience is required for exact listening comprehension. On the other hand, visualization of acoustic data, especially spectrogram is utilized in the domain of speech analysis, since the visualized information can be checked objectively, and easily recognized them with shallow experience.

There are two problems to visualize long-term acoustic data of equipment by using conventional visualization method represented by spectrogram. At first, it is difficult to discriminate different spectrograms of equipment unlike voice or music, since the equipment sounds, such as discharge sound and oscillating sound are similar continuous sounds. Figure 1 (a) and (b) show two spectrograms of two different electric discharge sounds. It was difficult to discriminate the difference. Our method uses classical spectral subtraction(SS)[1] as a pre-filtering of visualization to solve the problem.

Next problem is difficulty of detecting changing point in visualized image of long-term data. Conventional visualization methods of long-term data fix the form of time-series expression. For example, one-dimensional form with scrolling (fig. 2-(1)) is used most popularly. Multiple column form (fig. 2-(2))[3] or spiral form (fig. 2-(3))[2] are proposed. Visualized image of long-term data by the fixed form visualization is condensed and becomes to be miniature. Consequently changing points are embedded into fine texture of the visualized result, and user can not find signs of changing points.

In order to solve this problem, our method bends and extends layout form according to the change of data. The method generates an easily browsable view expressing intelligible tendencies and features of data by reflecting local characteristics of data to the form of view.

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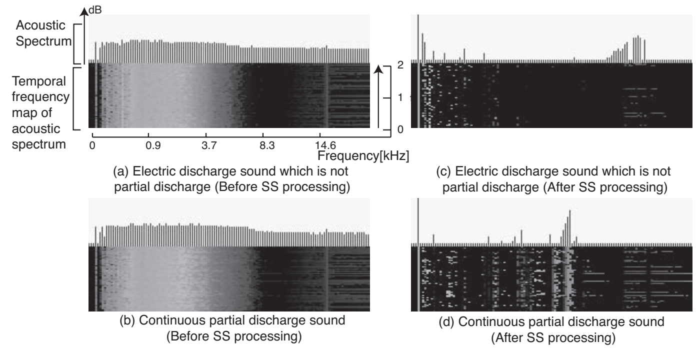

Figure 1: Spectrogram of electric discharge sound.

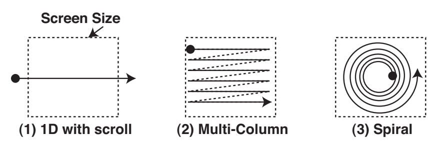

Figure 2: Conventional visualization scheme of long-term data.

2 Visualizing Long-term Sound Data

At first, the acoustic spectrum distributions of sampled sounds from long-term data are equalized for every frequency band, and let it be a "base spectrum". This base spectrum expresses the sound feature peculiar to the equipment. The base spectrum is removed from spectrum distribution of the archived sound data. By the subtraction, different sounds from the base spectrum is emphasized. Since long-term sound data contains several types of data according to multiple conditions of a target equipment, the method generates multiple base spectrums and user can select a base spectrum to emphasize their target phenomenon. Figure 1-(c) and (d) show spectrograms after subtraction of a base spectrum. User can clearly

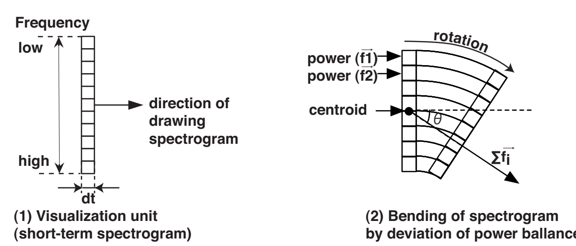

Figure 3: Visualization unit and bending effect.

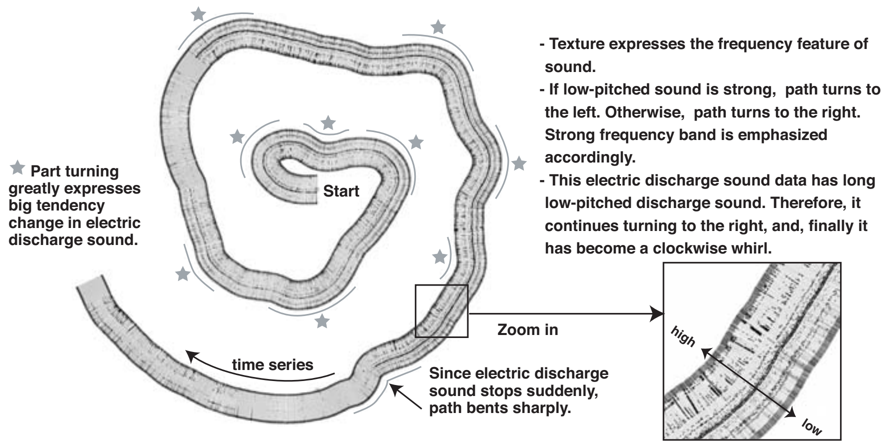

Figure 5: Visualization results of 1 hour and 19 minutes electric discharge sound by proposed method.

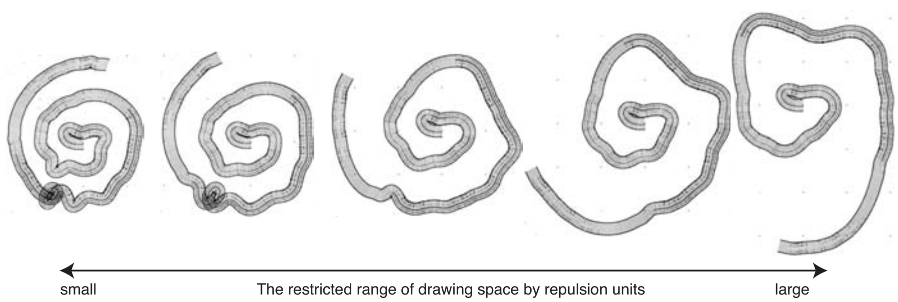

Figure 6: Visualization results by the different layouts of repulsion units for confining.

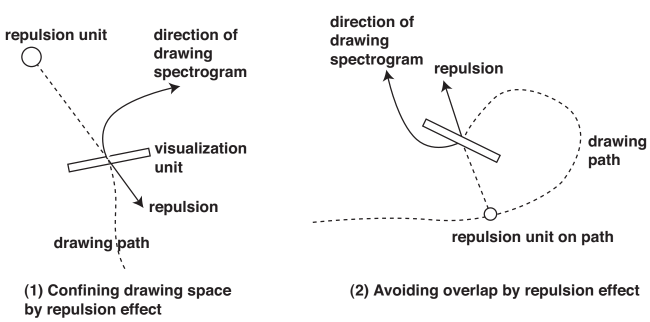

Figure 4: Role of Repulsion effect.

discriminate their difference.

After the pre-filtering, the method generates a visualized image by distorting spectrogram. The visualization unit of our method is short-term spectrogram (fig. 3-(1)). We use this visualization unit as a paint brush. The direction of drawing path is determined by the power balance of spectrum. We consider that the visualization unit is a rectangular rigid body, and the direction is determined with a moment when the power proportional to the amplitude of each channel is added as external force (fig. 3-(2)). By this effect, local feature of data reflects to the drawing path. Consequently different data sequence comes to have clearly different form.

By simply bending a path, the path sometimes overlaps or it will spread too large and browsability decreases. To avoid the problem, our method adopts the analogy of repulsion field like Coulomb force. Visualization unit has a quantity q_0 which serves as a base of repulsion (repulsion unit), and there is repulsion $k(q_0 q_1)/r^2$ between two repulsion unit q_0 and q_1 with distance r (k is a constant). And this external force is applied to movement of visualization unit.

In order to limit drawing to the compact range, repulsion units are arranged around an outside. If a visualization unit approaches the repulsion unit arranged at the perimeter, the power pulled back inside will work (fig. 4-(1)). Visualization image becomes compact as the result. In order to reduce overlaps and intersections, repulsion units are also arranged on the history at a fixed interval (fig. 4-(2)).

We applied 6 methods containing our method to visualize long-term electric discharge sound and compare their browsability in same size. The target data is an electric discharge sound recorded in order to evaluate insulating ability. Figure 5 shows an example of visualized image of 1 hour and 19 minutes data by the proposed technique. Bending parts of the figure express the changing points of data and it is easy to recognize the tendency of changes. Moreover, form modification helps to recognize the feature of the whole data. The global visualization form in the proposed technique changes by the definition of repulsion field (figure 6).

References

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