Preservation of Data in Gramophone Record by Non-contact and Non-destructive Fully Scanning Method

Shigeto Takeoka , Takanori Tokuno and Yoshio Yamasaki

Graduate School of Global Information and Telecommunication Studies, Waseda University
takeoka@acoust.rise.waseda.ac.jp

Abstract

The digital archiving is the major method in recording the analog records, but in usually it has a problem in itself that it destroys the object while running the stylus. Using the fact that the sound information in wax cylinders and analog records is recorded throughout the sound groove, we have tried modifying the Signal-to-Noise ratio [1]. Having these as our background, we are aiming for the establishment of a new method in which one could read as much information as possible off of wax cylinders and early SP analog records without making contact and destroying it. In this report, by fully scanning wax cylinder with laser beams we've tried to image the virtual record on computer from which we can make a replica if needed. And pick out as much information as possible from the recordings.

1. Introduction

In most cases, when playing a record normally, the differences in shapes of a recording stylus and playing stylus makes a total contact of playing stylus against the sound groove impossible meaning the sound informati-on is not taken out 100 percent. Also, as long as it is playing with contact, the deterioration of the object cannot be avoided. Especially when the object is a very damaged valuable heritage, there is a definite need of a recording without contact. The method using laser and tracking control and reading information of sound was experimented in 1984 by Ifukube, Asakura and others-[2]. But we think of preserving the historical heritage as precisely as possible, and it is also of importance to let the technology of the time decide the strategy in taking out the information from the object. In this report, we read not only the information recorded on the sound groove but on all the surface of the wax cylinder. We also try and improve the S/N of the reproduced sound, we make a very precise 3D information which would enable for a production of a complete replica.

2. Wax Cylinder

Generally speaking, a cylinder shaped recording media, called wax cylinder, records the sound wave into the depth direction of vertical vibration and spirally into the cylinder surface. A very widely spread cylinder records by Edison Co. was 56 mm in diameter and 105 mm in length. The recording time was separated into 2 min and 4 min types.

3. Experimental Equipment and Method

The originally made measurement equipment is shown on Fig.1. and that is composed of a laser displacement sensor, a rotating stage, a 1-axis-stage. We place a wax cylinder or a disc record on a rotating stage. And by moving a laser-head linearly while fixed towards the 1-axis-stage, we gain the 3 dimensional information of the total surface of the records. For a laser displacement sensor we used a red color semiconductor laser with a minimal spot diameter of 35x20m (Keyence co. LC-2440) and read the depth with 0.2 μ m resolution using a Position Sensitive Detector (PSD) sensor. The point of measurement is 76800 pts/1round, per 2.3 μ m for the wax cylinder, and per 10 μ m for 1-axis direction. Considering the regular rotation number of a cylinder, it equals to a sampling rate of about 184 kHz for a 2 min type and 205 kHz for a 4min type. Excluding the especially damaged ones, the records are washed by ultrasonic-wave(output 600W, frequency 26~100kHz) .

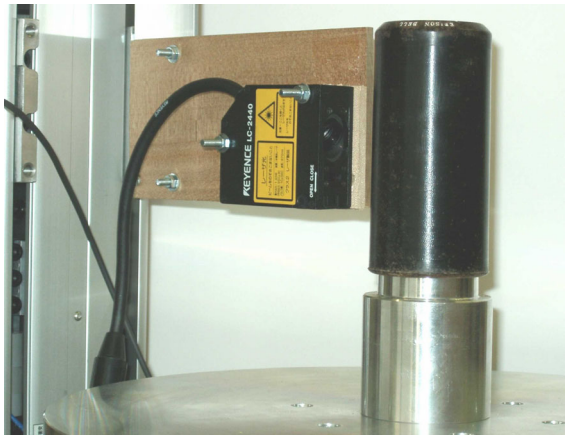
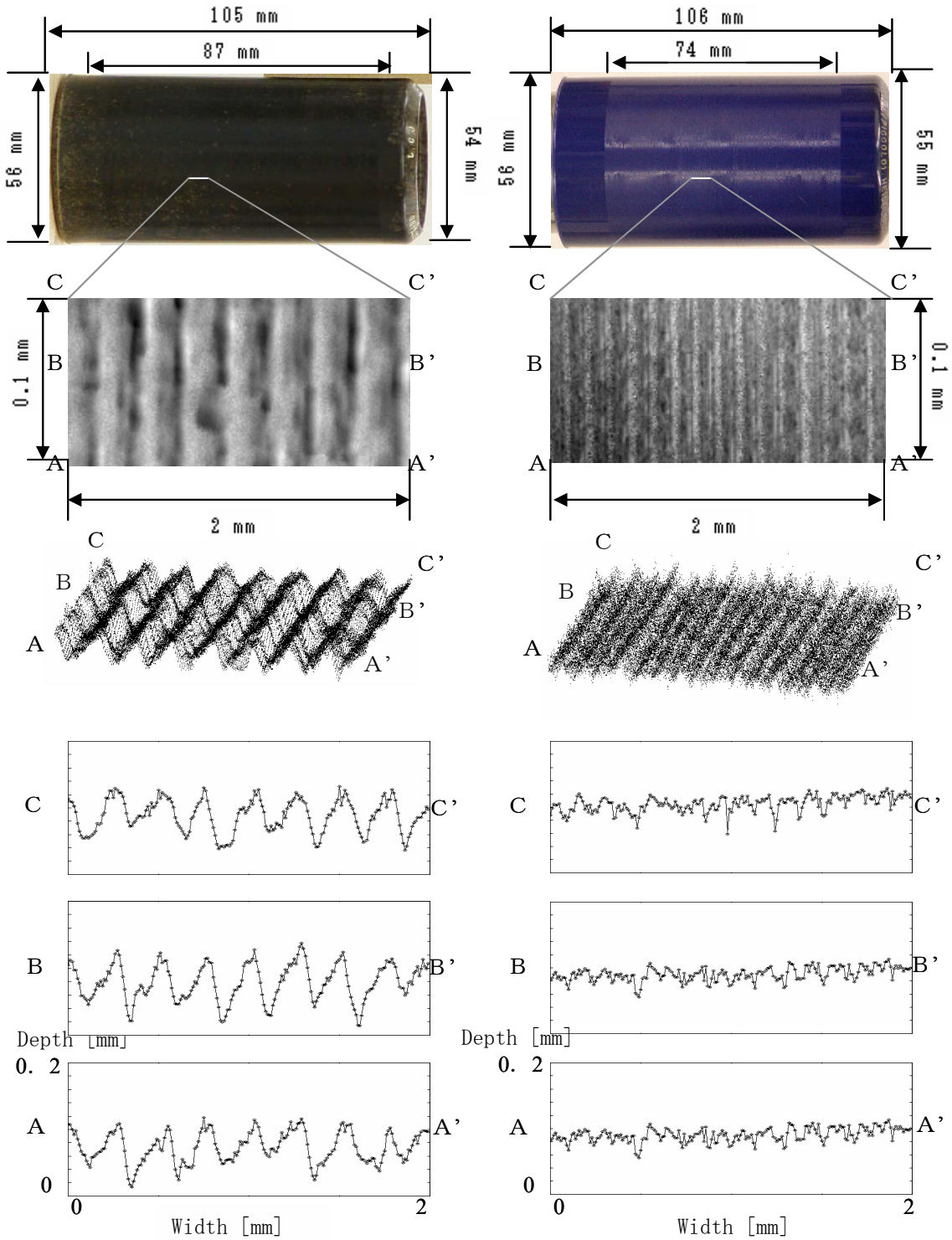


Fig.1. Measurement equipment.

4. The Result

Figure.2. shows a part of an experimental result after reading 2 min and 4 min types of wax cylinders. It shows the appearance and 3 dimensional information of the surface of each of the cylinders.

On the 3 dimensional information, the depth informati-on is expressed by the shades of darkness and lightness, and sectional view taken on the spots A-A',



(a)The Result (2min type). (b)The Result (4min type).

Fig.2. The result of the measurement.

B-B', C-C' is shown. Surface 3 dimensional features are able to see including the fact that 4 min type is recorded with about double the pitch of a 2 min type and the fact that due to the improvement of the reproducer, the sound groove of the 4 min type is dug shallower than that of a 2 min type.

4.1. Reproduction of Sound Information

About the highly preserved wax cylinder, we presumed that the position of sound groove can be obtained by connecting the highly correlated spots between the data of surface and the typical "prototype

shape" of the sound groove. The "prototype" is gained by averaging the data of the surface surrounding the deepest spot, looking across the sound groove, and in every groove all around the surface of the cylinder. The result is shown in Fig.3. The narrow linear line is the presumed data and it traces just about the center of the sound groove.

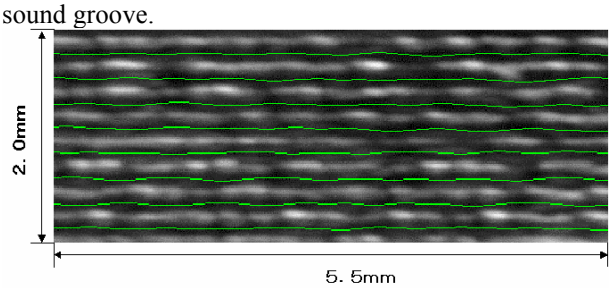


Fig.3. Presumed line.

Figure.4. shows the points at 10 μm intervals from the obtained center of the groove with dotted lines and average of them with a heavy line. Observing the averaged waveform, we can see the suppression of the noise which is caused from many kinds of delicate damages.

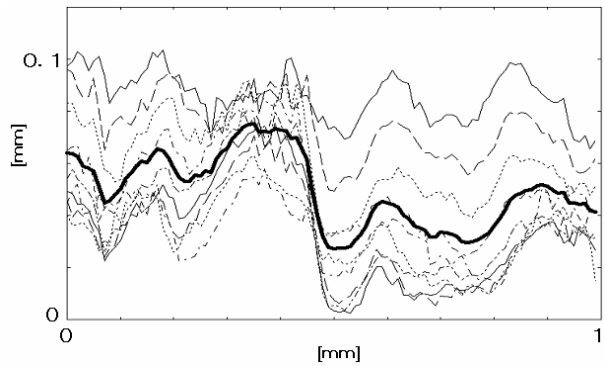
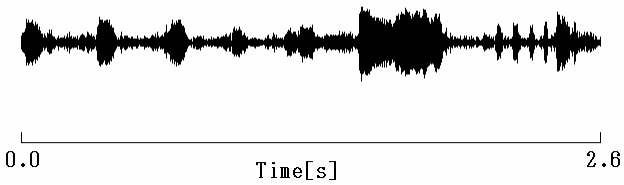
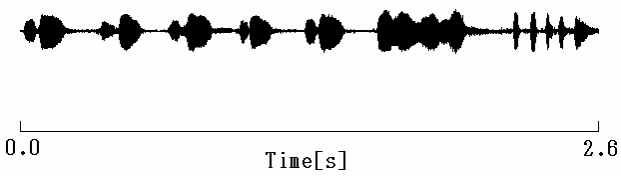


Fig.4. Averaging the Data.



(a). Reproduced sound.



(b). Played sound.

Fig.5. Comparison of waveforms.

We interpolated the obtained data into 128 points by using Sync function and Black-man window. And we got sound information by averaging the 300 interpolated data which was taken out from the deepest spots of the sound groove including the areas where no playing stylus can reach. And by using Generalized Harmonic Analysis (GHA) method, we got 300 frequency components.Figure.5.(a).shows the synthesized result of them, and Figure5.(b).shows the waveform of sounds played by regular stylus. A few wah-flutters due to the distortion of wax cylinder surface were produced, but we could hear the sound without any problem.

GHA is a method of frequency analysis proposed by Norbert Wiener in 1933[3]. By extracting a sine wave from the original signal which makes the power of the residual wave, frequency components of the original signal are calculated.

4.2. Introduction of Cluster method

The 2 min types were first made in 1888 and were made mainly of wax. There are many valuable things that have been kept for about 100 years and deteriorated or destroyed. Figure.6. shows the obtained data from a very deteriorated wax cylinder. It's difficult to specify the location of the sound groove by sight because it is changed and corroded heavily. In this chapter we presumed on the position of sound groove by introducing a cluster method.

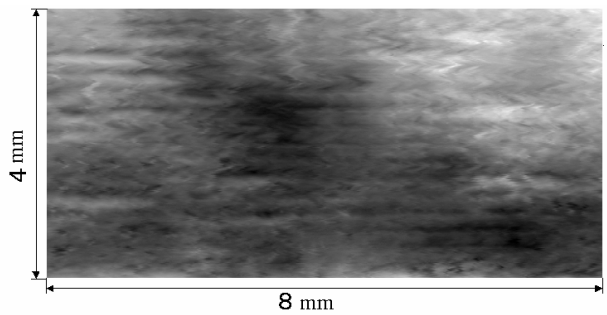
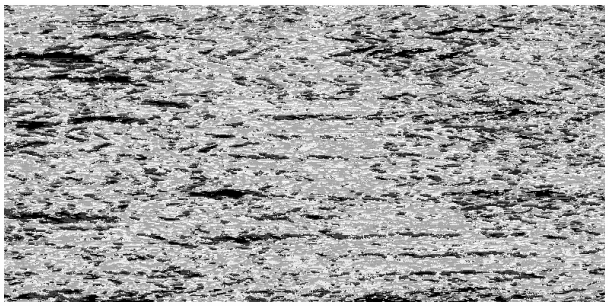


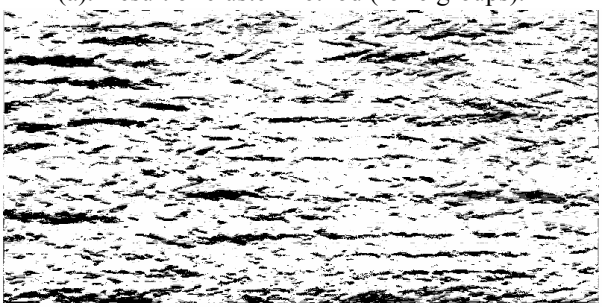
Fig.6. Data of deteriorated wax cylinder.

Cluster method is a classification method that can divide without external criterion. In this report, we use K-means method that divide some classes of the number that we assigned according to the square of Euclidean distance. We used cluster method to the all the data in Fig.6. The result of the clustering for 6groups is shown in Fig.7.(a). and from which we divided into 2groups is shown in Fig .7.(b). We can recognize grooves.

From the specialty that we can pick up the features by using this method from 3D information without external criterion, we are trying to extract sound information from objects like painting and pictures which are not made for sound recording purpose.



(a). Result of cluster method (for 6 groups).



(b). Result of cluster method (for 2 groups).

Fig.7. Results of cluster method.

4.3. Reproduction of the data from broken records

In this chapter, we examine the method to reproduction of the data from broken records.

Fig.8. Broken wax cylinder.

Figure.8. shows some pieces of broken wax cylinder. We measured the pieces which are attached to the rotating stage and presumed on the position of sound groove using the same method we used on chapter 4.1. We presumed on the location of each of the broken pieces by observing the correlation of the edge point placement of the sound grooves. In this case, we were able to decide on a single pattern of connections between the 9 shattered pieces. Other than the broken pieces shown in Fig.8, there are dust-size pieces which cause imperfections in the connection planes. Therefore, we need to interpolate the spaces in order to reproduce sound waves. Using the characteristic of GHA which the window doesn't matter, we presumed the length of the missing area from phase difference of frequency components of sound information included in each of the broken pieces. And we interpolated the missing area by using cross fades of frequency components. We interpolated the missing area of the broken wax cylinder and got the 3D image of the cylinder before it was broken. A part of them is shown in Fig .9. And from the 3D data we could get the sound information and recognize the content.

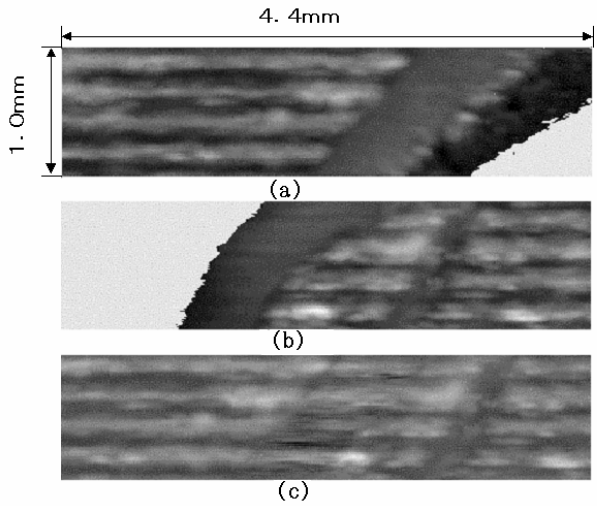


Fig.9. Interpolation of the 3D data.

5. Conclusions

By scanning the full surface with laser beam, we preserved an object "as it is" by non-contact and non-destruction.

We examined the method to reproduce the sound information.

We measured all over the surface of the wax cylinder without contact. By using the data of deep area where the playing stylus can't contact, we could reproduce the sound information from the damaged wax cylinder which was not able to play with a normal player. Now we are trying to get the vector component of sound information, using the simplicity of the system of the recording.

References

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[3] N.Wiener,"The Fourier Integral and Certain of its Applications ," *Dover Publication Inc*,1958.