Summer 2012 Study of Aluminum Transcription Discs

During the Summer of 2012, Alain Benninger, an electrical engineering student from the University of Applied Science in Fribourg, Switzerland, made a study of the aluminum transcription discs provided by Harvard. The goals of this study included,

1. Evaluate the groove profile across the 25 discs provided to determine how much variation exists.
2. Perform detailed scans of a small representative subset.
3. Extract audio from the subset and further develop the algorithms used for analysis.
4. Compare the extracted audio quality with that from stylus playback
5. Determine topics for further work.

All these goals were accomplished and are discussed in detail in Benninger's thesis [1]. Here we will provide a short summary of the results.

The aluminum transcription discs used in this study were primarily scanned using the 3D optical scanning system. 3D was chosen because the groove profile is complicated and does not give an easily interpreted image in 2D. For future considerations, 2D remains an option.

1. Figure 1 is a schematic comparison of the groove profile on an aluminum transcription disc with that of a "standard" 78 rpm commercial shellac pressing, of the same time period.

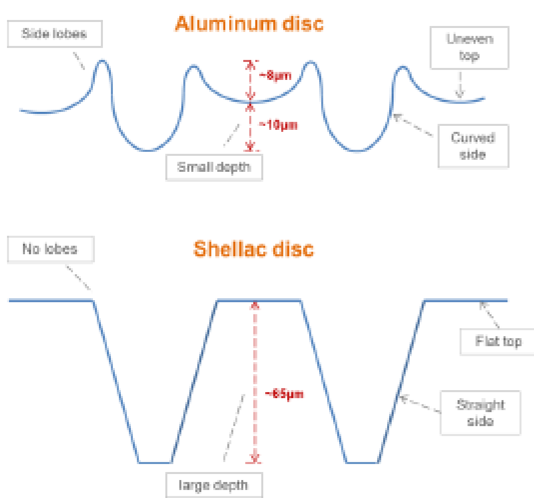

Figure 1: Top defines a generic groove profile for the aluminum transcription discs in comparison with the commercial shellac (bottom). For the latter, the groove is deeper and has sharply defined features.

Within the sample set a considerable variation was seen in the detailed profiles. All of these have been cataloged and a summary spreadsheet prepared. Three examples are shown in Figures 2-5. The conclusion is that robust algorithms will be required to handle this large sample variation.

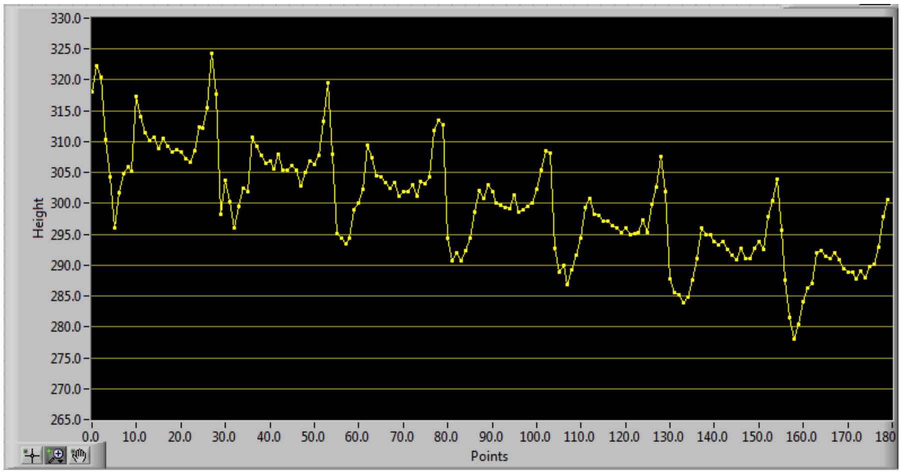

Figure 2: Disc 68 with asymmetric lobes and typical groove depth of 10 microns.

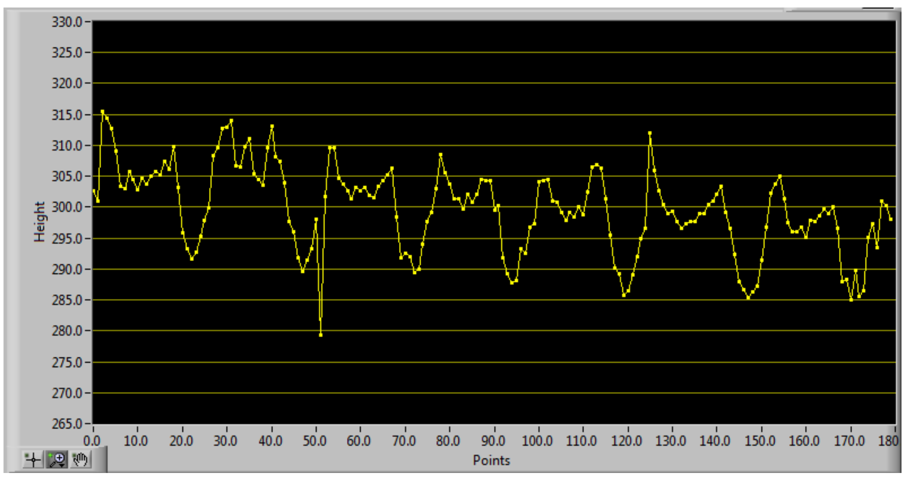

Figure 3: Disc 4147 with symmetric lobes and a groove depth of 10-12 microns.

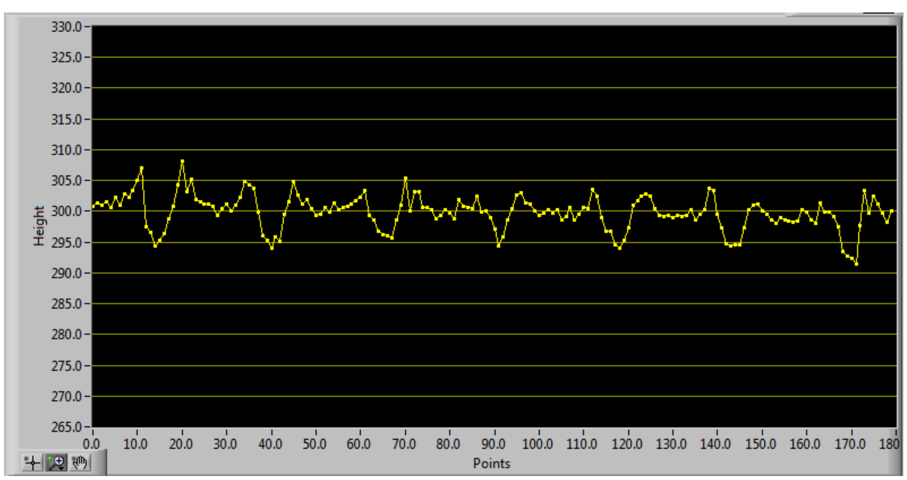

Figure 4: Disc 6765 with small lobes and a groove depth of 5 microns.

2. The sample set chosen for detail scans included items with a variety of characteristics as discussed above. There were five sides in the set: 68, 2991, 4147, 6756, and one referred to as “untitledDR”. Of these stylus versions were obtained for 68 and 4147. A considerable amount of work was done to study the response of the 3D probe and autofocus system to the reflective aluminum surface. An optimized measurement protocol was found. Since the grooves are small it was necessary to perform a set of interleaved scans, referred to as “Npass=4”. While this improved the data quality it took extra time to collect. The scans were performed at an effective time sampling rate of 46.8 KHz (standard CD’s are sampled at 44.1 KHz). This means the highest frequency measured was 23.4 KHz. It would be straightforward to increase the sampling to 96 KHz (often referred to as archival standard) at the expense of a factor of two in scan time. At the rate used, 2 hours were required to scan a disc side. To determine the duration of an organized scanning project one would need to consider the number of shifts/day and the possibility of running multiple machines in parallel. In addition, probe speed has increased dramatically already over the past few years. In any case, it appears that 3000 discs would be a multi-year project.

3. In order to analyze the Npass data, Benninger had to develop a number of new algorithms to combine data from the various passes, referred to as the “MatchAlu” process. Once the data was properly normalized, Benninger applied a variety of fitting and filter tools in order to determine the groove position at each time slice using selected data points. This was referred to as the “QuadAlu” process since it was based upon fitting the groove profile to a quadratic (parabolic) function. Benninger also developed some interpolation tools to pass over bad regions in time. The pre-existing software package for analyzing 3D data “PRISM” was modified by Benninger to include all these new features as options for the user. Figure 5 shows an aspect of the “outlier” filter Benninger applied.

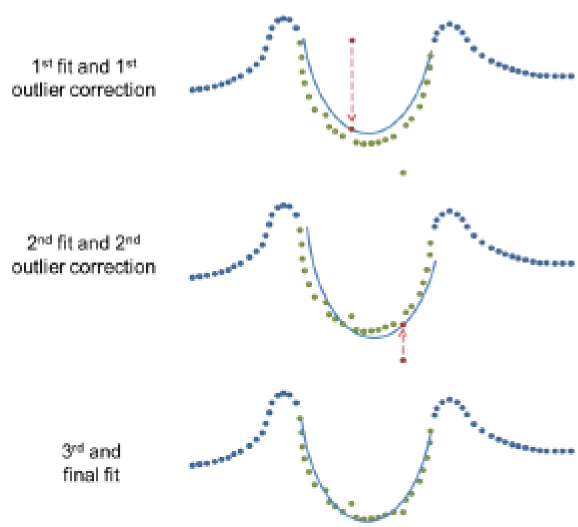

Figure 5: Principle of the outliner correction is shown here. Initially the outlier pulls the fit away from the main group of points. The outlier is forced to lie on the fit which is then re-calculated. A second outlier is then forced to the new curve which is then again re-calculated.

4. Audio was extracted from all the discs scanned. The results were reasonable although clearly some discrete noise pulses remain and sizeable high frequency noise can be heard. Interestingly the stylus versions were seen to have a dramatic drop in signal and noise above about 4 KHz. The comparison is shown in Figure 5 for disc 4147. If a similar frequency restriction is put on the optical versions they sound "similar" to the stylus versions. From the frequency spectrum we can see that some signal remains in the stylus version which is still unresolved in the optical counterpart. Some examples are posted at http://bio16p.lbl.gov/Parry.html

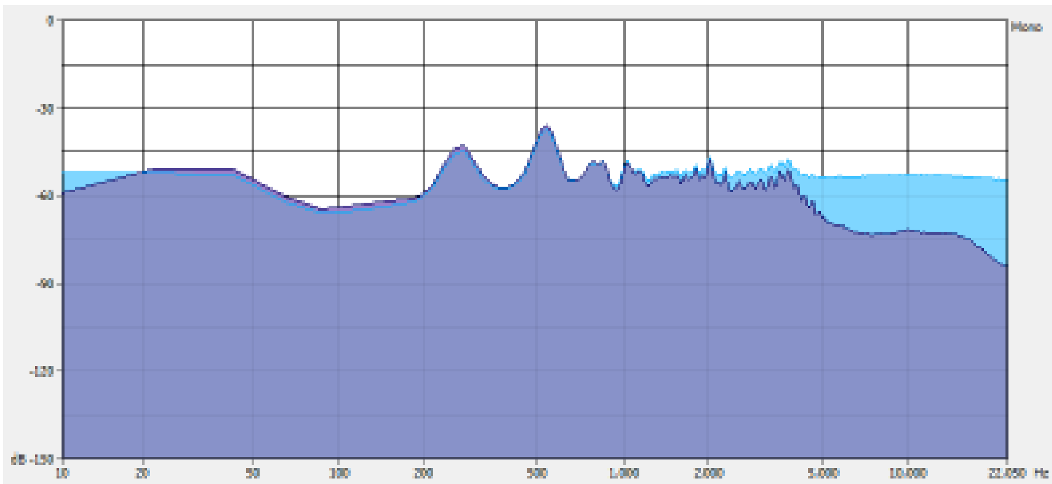

Figure 6: Comparison of optical (light blue) and stylus (purple) version of a portion of disc 4147. Note that above 4000 Hz the stylus version falls over 20 dB in ~2000 Hz. However, above 4000 Hz there are still some peaks resolve more significantly in the stylus version than the optical version.

5. Understanding the difference between the optical and stylus version is a key topic for further study. David Ackerman indicated that there may have been a low pass filter in use during the stylus transfers. The data quality and fitting procedures developed by Benninger can also be refined further to correct for additional outliers and interpolate in a more robust way. This term, a computer science student, Priyanka Nigam, is working to extend the analysis tools developed by Benninger. The goal is to improve the high frequency performance and study a larger sample set.

[1] Benninger, Alain, "2D and 3D Scanning of Metallic Records and Masters", Bachelor's Thesis August 2012, Ecole Ingeniers Fribourg