Optical Audio Reconstruction for Stereo Phonograph Records using White-light Interferometry

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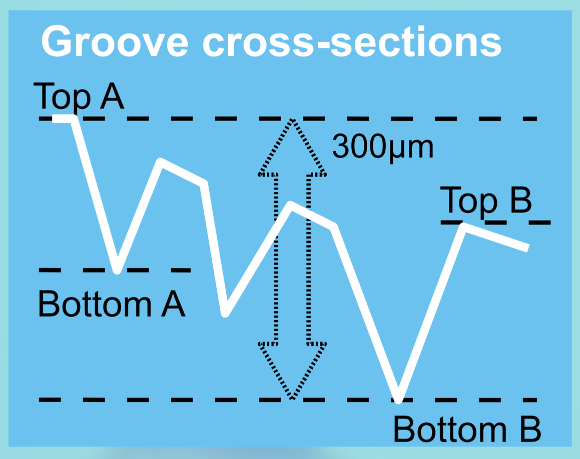
1. Background

Our Optical Audio Reconstruction (OAR) using white-light interferometry has successfully reconstructed a tiny stereo signal from a small area of an LP.

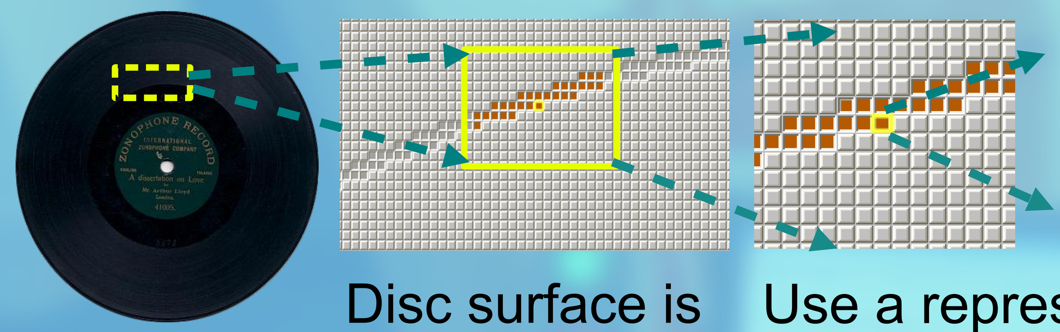
Challenge:
The workflow must be modified to scale up and handle a larger scanned area.

2. Large-scale Scanning

Problem:
Disc surface warping demands a greatly increased scanning depth, but this takes too much time.



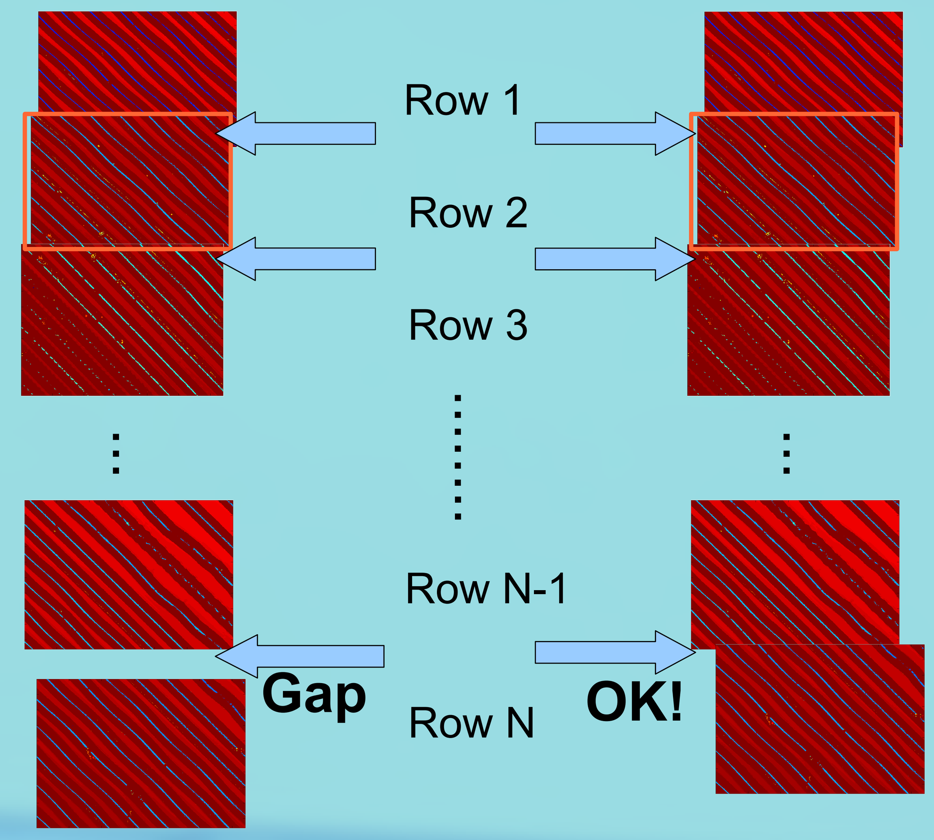
Solution: Hierarchical Scan



Disc surface is divided into *flat* sub-regions.

Use a representative FOV's scanning settings for the whole sub-region.

3. Image Alignment

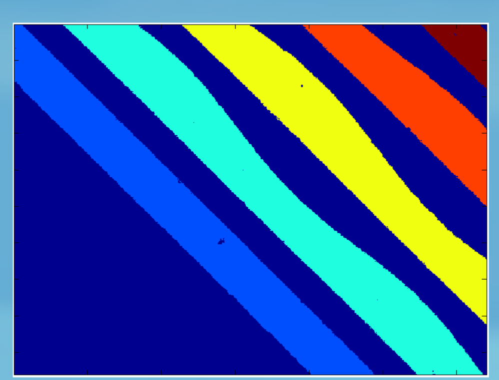


Greedy alignment introduces accumulated errors.

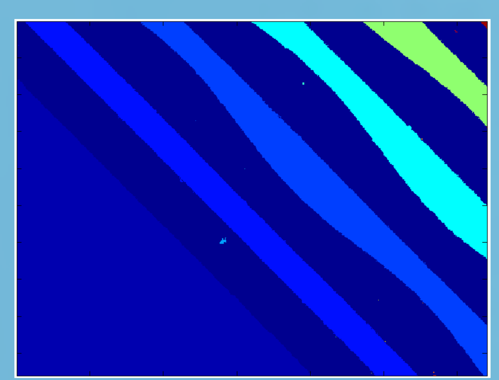
These gaps are eliminated during post-processing

4. Groove Recognition

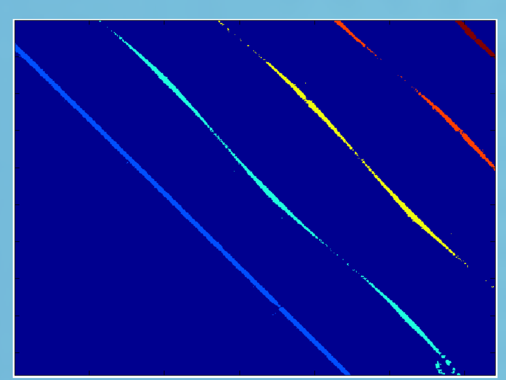
Original FOV



CC: Valley



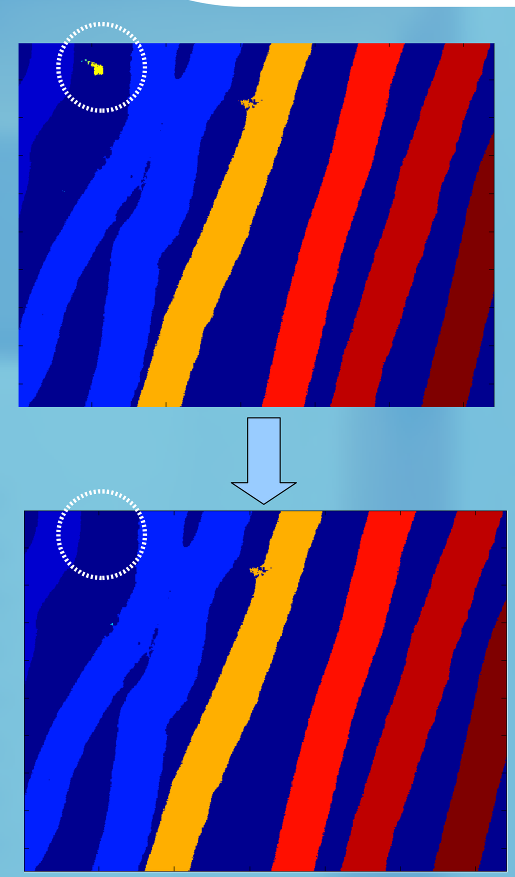
CC: Top



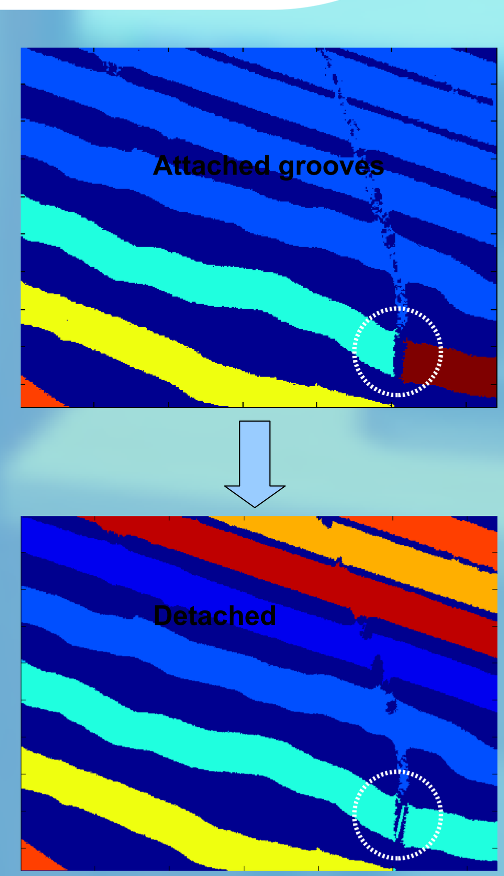
CC: Bottom

Identify the parts of the grooves with Connected Component (CC) Analysis.

5. Noise Removal

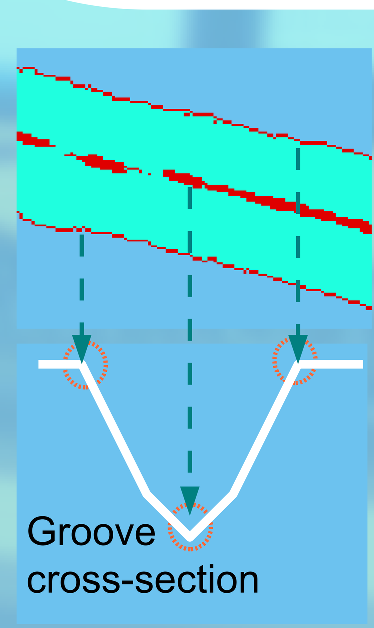


Remove CCs that violate expected topology.

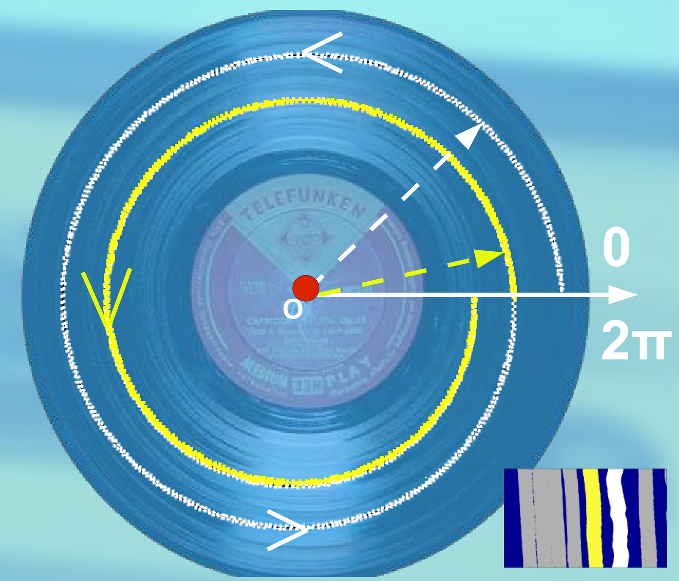


Detach and re-attach dust-affected grooves.

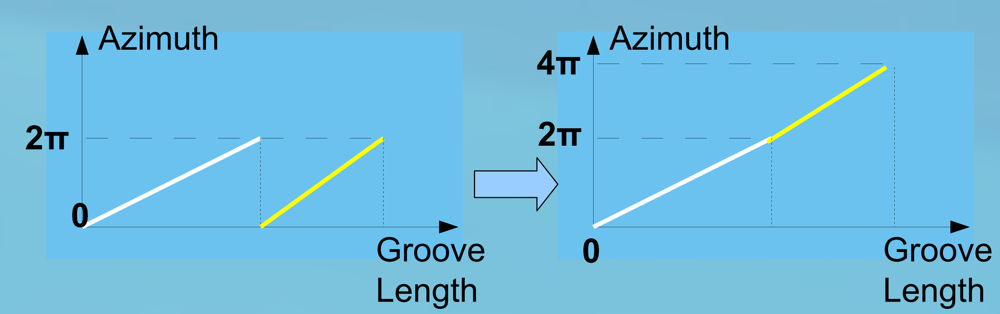
6. Undulation Extraction



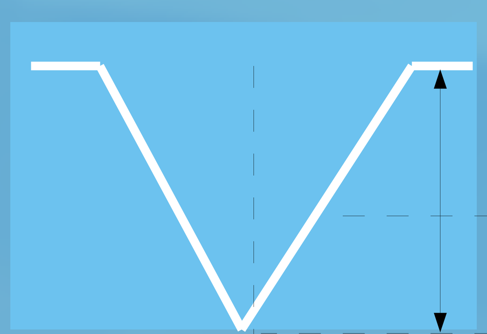
Edge Detection



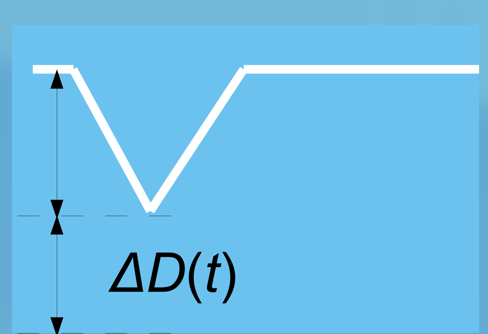
Trace grooves and unwrap phase between revolutions.



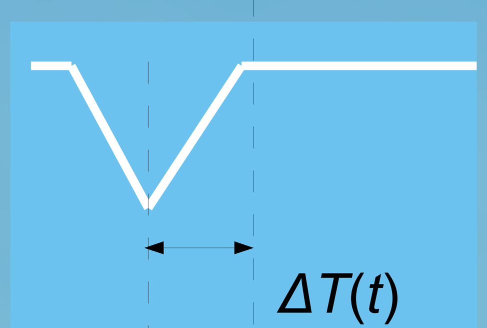
7. Audio Conversion



t1



t2



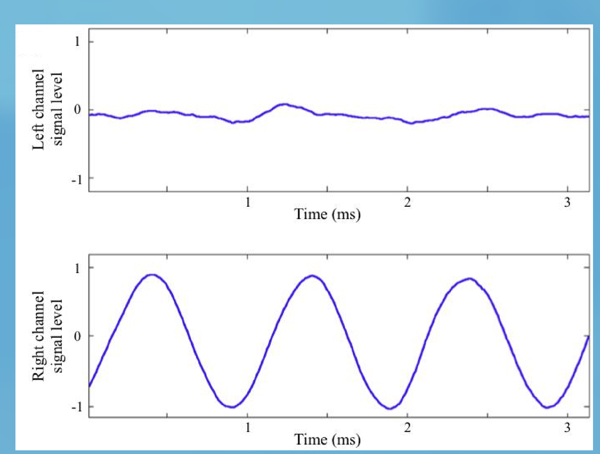
t2

Stereo Output

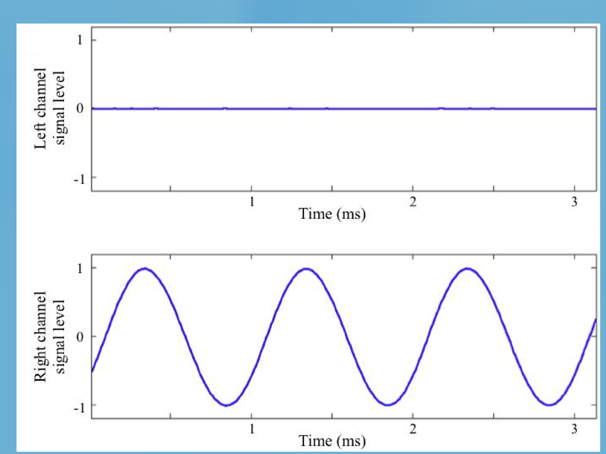
$$Channel_{left}(t) = \Delta T(t) - \Delta D(t)$$

$$Channel_{right}(t) = \Delta T(t) + \Delta D(t)$$

8. Results



Excerpt of stereo audio reconstructed using our OAR



Excerpt of digitized stereo audio output from turntable

9. Conclusion

Our white-light interferometry-based optical audio recognition system has successfully reconstructed digital stereo audio signals from LPs. Among future strategies of improving audio quality while decreasing scanning time:

1. Better center correction
2. Determining the minimum scanning resolution required
3. Using the groove width information to substitute for the noisy depth information

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