Audio recovery and identification of first Norwegian sound recording

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For Slides see eprints at Southampton University
Summary

• Description of Norwegian tinfoil artefact

• Background and overview of Sound Archive Project at University of Southampton
  – Cylinder and disc media scanning systems

• Scanning process for Norwegian Tin foil recording

• Audio recovery and audio clips

• Unusual features of Norwegian tinfoil

• Forensic investigation using historic records
Norwegian tinfoil artefact

- Tinfoil artefact donated to The Norwegian Museum of Science and Technology in 1936, by Peder Larsen Dieseth

- Inscription indicates that the artefact originated from first sound recording performed in Norway by Dieseth
  - 5th February 1879 by an Edison tinfoil phonograph at the Tivoli in Kristiania

- Tinfoil was glued to a paper mount, making it impossible to play using conventional stylus
Norwegian tinfoil artefact

• Sound Archive Project (2005-2009) at the University of Southampton used non-contact scanning methods for audio recovery from mechanical sound recordings

• Tinfoil artefact owned by the British Library Sound Archive successfully scanned in October 2008

• In 2009 The Norwegian Museum of Science and Technology and the National Library of Norway commissioned the Research Institute for Industry (University of Southampton) to scan their artefact and extract the audio content
Physical features of Norwegian tinfoil

- Gluing process damaged the surface of the artefact in series of large depressions and creases
- Tinfoil has some tears, both across and along grooves. Audio in these regions is lost
- Tinfoil is a single sheet measuring $132 \times 140$mm
  - drum diameter of approximately 40mm, assuming all of the sheet is present
  - Significantly smaller groove pitch than BLSA tinfoil (~1mm compared with ~3mm for BLSA)
- Tinfoil contains 6 distinct tracks
- Modulated groove structure (indicative of audio content) evident even by eye
Sound Archive Project

• Research project funded by EPSRC at the School of Engineering Sciences, University of Southampton between March 2005 and March 2009

• Scanning systems provide high resolution, non-contact surface mapping of mechanical sound recordings, to digitally preserve the surface and for audio recovery

• Supported by the British Library Sound Archive and TaiCaan Technologies, and in collaboration with a US-based project at Lawrence Berkeley National Laboratory

• General progress of project reported at JTS2007 in Toronto

• Two preservation systems developed during project:
  – Cylinder scanner
  – Air bearing system for disc media

• Continuation of research programme through commercial scanning for Tin Foil and Flat Discs

• Commercial Scanning of Cylinders by TaiCaan Technologies.
Sound Archive Project

- [http://www.sesnet.soton.ac.uk/archivesound/](http://www.sesnet.soton.ac.uk/archivesound/)

- Current studies.
  - Cylinder Recording of Queen Victoria
  - Early 5 inch Berliner Flat Disc Master #85
Wider Research Directions

- How to accurately measure the 3D geometries of structured surfaces. The key limitation is in the sensing of reflected light from highly sloping surfaces.

- How to collect sufficient data to represent the functionality of a surface.
Selected Refs


Sound Archive Project - cylinder system

- Cylinder mounted between conical centres
- Sensor moved across groove structure in a series of linescans
- Effectively unwraps cylinder surface into a planar surface
- Data processing techniques used to detect groove structure, and audio extracted from displacement data
Sound Archive Project – air bearing system

- System provides planar (x,y) travel of carriage on air bearing
  - Air bearing provided by ~5μm air ‘cushion’
  - Moving carriage fitted with a rotation stage
  - Sensor mounted on overhead granite gantry, whose height controlled by high resolution stage
  - 4 axis of motion, suitable for disc media
  - Tinfoil artefacts are scanned by operating in 3-axis mode (neglecting rotary stage)
  - Unlike wax/Amberol-type cylinder, tinfoil is already ‘unwrapped’ so flat bed scanning is required
Tinfoil mounted in scanning system

The tinfoil was positively located on the carriage using slips of cardboard taped over the edges. This stopped lateral movement of the tinfoil during the rapid acceleration of the air bearing carriage.

The sensor is required to be located close above the surface.
Preview scan, segmentation and movement

- Displacement sensor’s working range limited to 350µm
- With ~2.5mm height variation across surface, an automated segmentation routine is necessary to scan whole artefact
- In common with BLSA tinfoil, artefact had tendency to move over time (relaxation, temperature effects?)
- Rigid cylinder artefacts have not been observed to suffer from this process
- Some segments had to be re-scanned to ensure that surface was within range of sensor

Low resolution (0.5 × 0.5mm grid spacing) preview scan used to determine macroscopic form of surface. Colour coding in diagram represents height in mm.
Full resolution scanning

- Initial tests and calculations for audio recovery suggested appropriate grid resolution of 10µm grid spacing in x and y directions

- Full scan took 3 weeks of continuous scanning, with recurrent supervision to detect shape changes in the tinfoil

Surface height for 15mm length of tinfoil. Rectangular forms are evident, caused by segmentation

Gradient representation, to highlight groove structure
Merged data – full surface

Surface height data

Distance along ‘cylinder’, across grooves (mm)

Distance along ‘cylinder’, circumference along grooves (mm)

Track1
Track2
Track3
Track4
Track5
Track6

Gradient of surface height data
Audio recovery

- Normal audio extraction procedure:
  1. Locate groove trajectories
  2. Generate groove matrix – e.g. at each linescan, select 30 points either side of groove centre
  3. Displacement track taken from vertical height of the groove bottom (sometimes lowest point of groove, or the mean of the nearest points in the groove centre)

- ‘Normal procedure’ proved to be rather disappointing

- Feature-tracking algorithm developed, based on correlating consecutive groove cross-sections, rather than following step 3 above

- Sample frequency speculative as size of tinfoil is unlike the 5” drum for the BLSA tinfoil
Audio tracks

- Displacement data de-crackled and de-hissed using specially programmed filters
- Further restoration of audio performed at National Library of Norway

Time history (top axis) and spectrogram (lower axis) for track 1
## Audio tracks – summary of content

### Track listings, lengths and description of content

<table>
<thead>
<tr>
<th>Track</th>
<th>Track length (samples)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track1</td>
<td>387153</td>
<td>Music, perhaps brass instrument</td>
</tr>
<tr>
<td>Track2</td>
<td>346566</td>
<td>Male speech</td>
</tr>
<tr>
<td>Track3</td>
<td>243918</td>
<td>Perhaps speech/singing plus music. Maybe evidence of track discontinuity?</td>
</tr>
<tr>
<td>Track4</td>
<td>179018</td>
<td>A few notes from a brass instrument</td>
</tr>
<tr>
<td>Track5</td>
<td>32635</td>
<td>Just 2.5 grooves, no obvious audio content</td>
</tr>
<tr>
<td>Track6</td>
<td>69101</td>
<td>Crackle, no obvious audio content, regular drumming noise probably caused by loss of data where tinfoil is missing</td>
</tr>
</tbody>
</table>
Tinfoil anomalies

• Analysis of measured grooves found little evidence of lead-in or lead-out grooves for the 6 tracks
  – Most tracks appear to start and end at the edge of the tinfoil, possibly suggesting that some of the tinfoil is missing

• Adjacent grooves were observed to exhibit differences in level of surface modulation, where gradual changes would be more expected

• The size of the tinfoil is very different to the tinfoil owned by BLSA – perhaps further evidence of loss of a portion of the tinfoil
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imorgen Formiddag mens K. 12.
Knut Tivander.

Fonografen
forevises hele Dagen paa Tivoli. Entré
25 Øre.

Anders Grandahl
Fonografen.

Man saa allerede for en tid siden i et af vores Dagblades Beretning om, at Fonografen, denne Nutidens mest vidunderlige Opfindelse, skulde være forevist inden en mindre Aarlds her i Kristiania. Da dette Instrument stikkertig endnu kun foresendes i ynderst saa Exemplarer paa denne Side af Atlantehavet, og hertilands uden at dog blot i dette ene Exemplar, vilde dets Eier visse nok gjøre sig det store Publikum meget forbunden, om han vilde give det Anledning til at gjøre Selvindslab med denne Triumph for den moderne Videnskab. Man kan selvfølgelig ikke vente, at Apparatets Eier gratis vilde aflese Tid og Penge for at vise Publikum denne Æskekommenhed, men man maatte naturligvis holde ham skadeslos ved en passende Entree.

Man tillader sig derfor velvilligt at hensige til Bekommende, hvorfor det kan lade sig gjøre, i et passende Lokale at forevise Fonografen.

I steres Navn.

Nasjonalbiblioteket
Dette stumfilmplate er en av de første fotografiplate som ble avlagt av en Edison-filmografi i Norge. Platen er vald inn en av undersøkningene på en de monstrasjon som ble avhøpt på Tevoll i Kristiania 1879.

Gustav Vigelens. Museum.
Bilde den 5. november 1879.
Red. Dines.
Okt. 1879.
Edisons Fonograf

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Thank you