Sound Design in Our Sound Environment: Soundscape Design, Auralisation and Evaluation in Environmental Acoustics

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Seminars on the Occasion of Ludvig Elblaus’ PhD Defence
Media Technology and Interaction Design, KTH, 24 May 2018
Sound Mapping:

dB (A), Ldn, Lden, Lnight, LA10(18hour)…
Auralisation

- **Auralisation** is to sound what **3D visualisation** is to vision.
- Auralisations are **easier for us to interpret** - they involve **listening** rather than metrics.
- They help us to **understand** and **better design proposed changes to an acoustic environment** and the resulting perceived **soundscape**.
Auralisation Workflow

Sound Source Recordings
Auralisation Workflow

Sound Source Recordings

Representations of Sound Propagation
Auralisation Workflow

Sound Source Recordings

Representations of Sound

Propagation

Calibrated Spatial/360

Soundscape Synthesis
Soundscape Auralization: Subjective Evaluation
Soundscape Auralization: Site Survey and Soundwalk
Soundscape Auralization: Virtual Soundwalk

- **Semantic Differential** pairs used to demonstrate equivalence with actual soundwalk experience: E.g., (Weak-strong); (Quiet-Noisy); (Static-Changing); (Rural-Urban).
- Can be time consuming to use and explain; unintuitive; inappropriate for non-experts.
Soundscape Auralization: Virtual Soundwalk

- **Semantic Differential** pairs used to demonstrate equivalence with actual soundwalk experience: E.g., (Weak-strong); (Quiet-Noisy); (Static-Changing); (Rural-Urban).
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- **Self Assessment Manikin (SAM)** derived from 18 SD pairs - three dimensions of emotion:
  - Valence – how pleasant
  - Arousal – how exciting
  - Dominance – how in control
- Intuitive, efficient, cross-cultural, equivalent to SD tests.
Self Assessment Manikin: Soundscape and Emotional Response

<table>
<thead>
<tr>
<th>Location</th>
<th>Site</th>
<th>Clip A Sound Sources</th>
<th>Clip B Sound Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalby Forest (Rural/Natural)</td>
<td>1. Low Dalby Path</td>
<td>Birdsong, Owl Hoots, Wind</td>
<td>Birdsong and honking, Insects, Aeroplane flyby</td>
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<td></td>
<td>2. Staindale Lake</td>
<td>Birdsong, Wind, Insects, Single car</td>
<td>Insects, Birdsong, Water</td>
</tr>
<tr>
<td>North York Moors (Rural/Suburban)</td>
<td>3. Hole of Horcum</td>
<td>Birdsong, Traffic, Bleating</td>
<td>Birdsong, Traffic, Conversation</td>
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<td></td>
<td>4. Fox &amp; Rabbit Inn</td>
<td>Traffic, Car door closing, Car starting</td>
<td>Traffic, Footsteps, Car starting</td>
</tr>
<tr>
<td>Leeds City Centre (Urban)</td>
<td>5. Smiddy Hill, Pickering</td>
<td>Traffic, Car door starting, Conversation</td>
<td>Birdsong, Distant traffic</td>
</tr>
<tr>
<td></td>
<td>6. Albion Street</td>
<td>Busking, Footsteps, Conversation, Distant traffic</td>
<td>Workmen, Footsteps, Conversation, Distant traffic</td>
</tr>
<tr>
<td></td>
<td>7. Park Row</td>
<td>Traffic, Buses, Wind, Busking</td>
<td>Busking, Footsteps, Conversation, Distant traffic</td>
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<tr>
<td></td>
<td>8. Park Square</td>
<td>Birdsong, Traffic, Conversation, Shouting</td>
<td>Workmen, Traffic, Conversation, Birdsong</td>
</tr>
</tbody>
</table>

To what extent does the soundscape belong in each of the following categories?

<table>
<thead>
<tr>
<th>Natural/animal</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial/mechanical</td>
<td></td>
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</tbody>
</table>
Self Assessment Manikin: Soundscape and Emotional Response

Self Assessment Manikin: Soundscape and Emotional Response
Real-Time Sound Level Monitoring: Scarcroft Road, York
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Real-Time Sound Level Monitoring: Calibration
Green, M. C., and Murphy, D. T., "EigenScape: A Database of Spatial Acoustic Scene Recordings", *Applied Sciences, Special Issue on Sound and Music Computing*, 7(11), 1204, 2017.
EigenScape: A Database of Acoustic Scene Recordings

- Recordings made with MH Acoustics Eigenmike.
- 4th-Order Ambisonics – High spatial resolution
- 8 examples of 8 different scene classes: Beach, Busy Street, Park, Pedestrian Zone, Quiet Street, Shopping Centre, Train Station, Woodland.
- 10 minutes per scene, 24-bit / 48 kHz.
- https://zenodo.org/record/1012809

Green, M. C., and Murphy, D. T., "EigenScape: A Database of Spatial Acoustic Scene Recordings", Applied Sciences, Special Issue on Sound and Music Computing, 7(11), 1204, 2017.
EigenScape:
A Database of Acoustic Scene Recordings
EigenScape: A Database of Acoustic Scene Recordings

- Spectral feature extraction (MFCC)
  - MFCCs (20 per frame)

- Spatial Feature Extraction (DirAC)
  - Azimuth Estimates $\theta$ (x20)
  - Elevation Estimates $\phi$ (x20)
  - Diffuseness Estimates $\psi$ (x20)

- 2048 sample frames, 50% overlap.
- Classifiers trained to identify scene class of 30s audio segments.
- Performance of classifiers trained using each feature set compared.
EigenScape: A Database of Acoustic Scene Recordings

- Spatial features (Elevation/Diffuseness) outperform spectral (MFCC-GMM) in majority of scenes.
- Spectral similarity and spatial similarity not the same.
- Good, but not perfect, accuracy validates EigenScape.
Cochlea Unwound: A Sonic Crystal Listening Aid
http://liminal.org.uk/
Redesigning the Landscape of Stonehenge
Redesigning the Landscape of Stonehenge
A303 Sound Demonstrations
Location 1 - Stonehenge

The following sound demonstration is for Stonehenge, looking towards the A303 before and after the scheme opens.

In this first video, "Without Scheme", you will hear road traffic flowing on the A303.

In the second video, "With Scheme", the road traffic uses the tunnel and vehicles can no longer be seen.

In the third video, "With Scheme and Tourists", visitors at Stonehenge can be heard close behind you talking and listening to the handheld electronic guides. These have been included to provide additional context.
Sound Design in Our Sound Environment: Summary

- Efforts to improve our sound environments should focus on **quality** rather than **quantity**, and acoustic design should aim to reflect this.
- Auralisation can help us clearly **communicate design options**, and enable people to **understand what acoustic designs** mean for them.
- Auralisation enables us to **listen** to the many different sound environments we inhabit – and so better **understand the emotional affect** they have on us.
- Established soundwalk methodologies can be supplemented with more **controlled, quantitative and objective soundscape assessment** strategies.
- Auralisation enables **improved acoustic and soundscape design**.
- **Real-time soundscape data** helps to build a more complete understanding of our urban environment as part of this process.
Thank You!

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Acknowledgements:
Marc Green, Yang Fu, Francis Stevens, Sorrel Harriet, Seb Jouan, Frances Crow, David Prior, Justin Abbott, Lu Yang, Iain Laird, and all AudioLab researchers.