RAINWIRE PROTOTYPE:
AN ENVIRONMENTAL SONIFICATION SYSTEM

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THE WIRED LAB
Intro

- Developing prototype Acoustic Rain Gauge (ARG) using long wire instruments
- Emphasis on climate change issues & agriculture
- Experimental approach: Technological appropriation (Eglash et al. 2004) of agricultural objects for sound art & science
- Cross-cultural investigation of rainfall as medium for artistic, cultural & scientific exchange. “Culturally Situated Sensing” (Jalbert 2011)
- Presenting research and reflections on new prototype
Aim

• Novel form of rainfall monitoring using landscape scale “long wires” / storm harps / giant Aeolian harp
• Enhance existing techniques / improve existing raingauge limitations
• Current investigation inspired by art/science practice: Creativity & Complexity (Burraston 2012)
• Method : Repurposing / Vernacular Engineering (Eglash et al 2004) using fencing materials / power poles / simple construction method / suspended cable
• Acoustic / *environmental sonification* of rainfall
• Direct translation of rainfall patterns to sound
• **NOT mediated through data**
Background

- Foundations in sculpture, land art, complex systems science, music composition
- Aeolian harps: Ancient Greeks & re-emergence in Romantic period
- Incorporated into buildings & castle grounds in England, Germany & Italy
- Romantic poets & physicists: Hoffmann, Kerner, Gattoni, Shelley and Goethe
- Domestic installations to large scale gigantic storm harps
- Gattoni (1875) Armonica Meteorologica naturale experiments with 100 metre long wires of varying diameters & materials: research and ‘sound’ weather predictions (Como, Italy)
- According to Gattoni wires become silent during rain
- BUT modern technology enables the rain sounds to be heard (&measured?)

http://ppp.unipv.it/Mostra/Pagine/Pagine%20Riferimento/VPLTArif12.htm
Background

• Idea developed recording rain ‘playing’ long wires for my compositions
• Proof of concept : temporal & spatial complexity
• Environmental sonification great potential to measure rainfall accurately
• & address recognized equipment shortcomings
• Could provide significant advancement to knowledge of rainfall event profiles, intensity & microstructure (i.e. did 100mm fall in 10mins or 24 hours?)
• Very important for estimating soil erosion & run off
• Challenge lies in identifying distinctive sound patterns & relating to rainfall events
• Beyond sonification of data, embeds technology & information within cultural contexts
• Adapt to range of cultural contexts / developing nations / water management / agriculture / weather / ecosystem monitoring industries

• Major influence has been underwater acoustic rain gauges ...
• Rain makes a unique sound / spectral signature falling on oceans
• Acoustic detection crucial to difficult problem of monitoring ocean rainfall
Dr. Jeffrey A. Nystuen

Listening to rain underwater

The Underwater Sound of a Thunderstorm

Observed Drop Size Distribution

Acoustical Inversion for Drop Size Distribution

Sound Level at 5kHz (dB)

Acoustic Interpretation

Date (Jan 1994)
exreme rain (200 mm/hr)

rain (40 mm/hr)

rain (4 mm/hr)

drizzle

wind (10 m/sec)

wind (6 m/sec)

extreme rain with bubble effects (200 mm/hr)
Let's look at some pictures of new prototype...
Tensioning pole

Far end pole is here!
Approx 175 metre span
Waterproof piezo contact mics

Ratchet tensioner
Piezo ceramic elements soldered and attached
Waterproof sealant
Far end pole is here! Approx 175 metre span
Piezo preamps & field recorder
<table>
<thead>
<tr>
<th>Product</th>
<th>Wire Diameter</th>
<th>Coil Length</th>
<th>Breaking Strain (lb/kg/kN)</th>
<th>Recommended Tension (lb/kg/kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible Longlife</td>
<td>2.50mm</td>
<td>1500m</td>
<td>830/377/3.7</td>
<td>300/136/1.3</td>
</tr>
<tr>
<td>Tyenny Longlife</td>
<td>2.50mm</td>
<td>1500m</td>
<td>1210/540/5.4</td>
<td>400/180/1.8</td>
</tr>
<tr>
<td>2.80mm Longlife High Tensile</td>
<td>2.80mm</td>
<td>1000m</td>
<td>1800/800/8.0</td>
<td>450/204/2.0</td>
</tr>
<tr>
<td>3.15mm Longlife</td>
<td>3.15mm</td>
<td>750m</td>
<td>675/300/3.0</td>
<td>270/122/1.2</td>
</tr>
<tr>
<td>4.00mm Longlife</td>
<td>4.00mm</td>
<td>500m</td>
<td>1080/480/4.8</td>
<td>400/180/1.8</td>
</tr>
</tbody>
</table>
Qualitative analysis

...environmental change is monitored using rules of thumb and qualitative indicators (Bohensky & Maru 2011) referring to Traditional Ecological Knowledge of the Inuit

- Prototype built in Nov 2014
- Two stereo recordings: https://soundcloud.com/thewiredlab/sets/rainwire-prototype
- Both rain events evening 20 Jan 2015
- Light Rain 74mins
- Moderate to Light/Moderate 14mins
- Rough Spectral plot of both events &
- Simple Digital Signal Processing (DSP) analysis: 14 mins on single channel each event
- No rain gauge / weather station on site (to be installed mid 2015)
- We can look at local weather radar images of light rain event...
• More detailed frequency spectrum of first 14 mins
• Some noticeable frequency bands
Identifying frequency bands using spectrogram analysis software (Praat) & manual graphic / parametric eq listening experiments (Logic Pro)

wind & lower freq <750Hz
lower band 750Hz - 2.5Khz
mid band 2.5kHz - 4.3kHz
upper mid band 4.3kHz - 6.5kHz
high band 6.5kHz - 11kHz
upper high band 11kHz - 14kHz
everything else 14kHz - 22kHz

Performed intensity analysis on frequency bands...
Mean Intensity for light rain event – 20 Jan 2015
Mean Intensity for moderate to light/moderate rain event – 20 Jan 2015
Conclusions & Reflections

• Dedicated Rainwire prototype hardware construction complete
• Initial qualitative analysis shows frequency dependant intensity wrt rain intensity
• BUT 15 min soundfile very taxing DSP-wise!!
• Significant differences between rainwire and standard rain gauges (point source due to small surface area) – closer affinity to ocean based ARG
• Piezo elements cheap, BUT some degree of variability in frequency response, needs to be standardised regarding process/frequency calibration + detachable?
• Large task requires collaboration with scientists / engineering / meteorological disciplines
• e.g. Nystuen 17-month field study in Miami & Ionian sea experiment has been ongoing since 2004. Black et al [1997] "beginning of a detailed analysis" looked at acoustic data collected between 1988 – 1995
Future Work

• Weatherstation / tipping bucket raingauge to be installed mid 2015 (help enable quantitative analysis)
• Dedicated data logging PC computer + realtime DSP/ ucontroller front end e.g. arduino
• Contact mic waterproofing alternatives to co-polymer sealant e.g. Sugru [https://sugru.com/](https://sugru.com/)
• Determine a minimal size! e.g. 16metre ??
• Key academic/industry contacts requirements - e.g. physics group interested in non-linear cables / wire manufacturers/ corporate / arts / DSP/ meteorological
• Indigenous contacts for cross cultural discussions / research
• Natural alternatives to wire ?
• Sponsorship: Grants / Industry / Academia
• Project updates via dedicated blog : rainwire-project.blogspot.com
Bibliography / Refs

• http://noyzelab.blogspot.com.au/2012/02/creativity‐complexity‐part‐2‐rainwire.html (RAINWIRE EXAMPLE SOUNDFILES)
• DSP intensity & spectral analysis with Praat software : http://www.fon.hum.uva.nl/praat/
• Whole soundfile analysis in colour with Spek software : http://spek.cc/
• Piezo bimorph vibration sensor: http://au.rs‐online.com/web/p/vibration‐sensors/0285784/
Acknowledgements

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• Alan Lamb discussion & collaboration on earlier long wire instruments (2008 – 2011)
• Uli Wahl: http://www.windmusik.com/html/longstr.htm (discussions & web page about Gattoni & long wires)

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