LISTAHÁSKÓLI ÍSLANDS
Iceland Academy of the Arts

Hljóðfræði IB – Acoustic design

Music and engineering

Hljóðfræði IB
08. Október 2013
Þráinn Hjálmarsson

About the course

Í áfanganum verður unnið með nemendum verkfræðideildar Háskóla Íslands að útfærslu samstarfsverkefnis þar sem sett verður fram ætlun um hljóðhegðun hlutar eða rýmis útfrá listrænni hugmynd og útfærslan útfærð með aðstoð greiningartækja og verklags verkfræði. Nemendur öðlast reynslu í að móta hugmynd um hljóðhegðun og fullvinna í samstarfi við verkfræðinema þar sem útkoman verður áþreyfanleg, eða kannski frekar áheyranleg, í listaverki.

Lecturers:

- Þráinn Hjálmarsson, composer and instrument designer
- Halldór Úlfarsson, visual artist and instrument designer
- Hans Jóhannsson, violin maker
- Einar Rúnarsson, stage manager in Harpa
- Dr. Fjóla Jónsdóttir, teacher at University of Iceland

About the course

Week 1

Tuesday. – Oct 8th - *Inngangur að áfanganum, fyrirlestur um hljóðfæri/hljóðrými og eðlisfræðihugtök um rýmishegðun kynnt.*

Thursday – Oct 10th - *Halldór Úlfarsson lectures*

Week 2

Tuesday – Oct 15th – *Hans Jóhannsson lectures*

Thursday – Oct 17th – "*I am sitting in a room"*

Week 3

Tuesday – Oct 22th – *Site visit: Einar Rúnarsson guides us through Harpa*

Thursday – Oct 24th – *Dr. Fjóla Lectures*

Week 4

Tuesday – Oct 29th – *Working on the project*

Thursday – Oct 31st – *Working on the project*

“Can architecture be heard? Most people would probably say that as architecture does not produce sound, it cannot be heard.

But neither does it radiate light and yet it can be seen. We see the light it reflects and thereby gain an impression of form and material. In the same way we hear the sounds it reflects and they, too, give us an impression of form and material. Differently shaped rooms and different materials reverberate differently.”

-Steen Eiler Rasmussen – Experiencing Architecture (1959)

“In Planning for good acoustics Hope Bagenal explains why the acoustical conditions of such a church must by their very nature lead to a definite kind of music. When the priest wished to address the congregation he could not use his ordinary speaking voice. If it were powerful enough to be heard throughout the church, each syllable would reverberate for so long that an overlapping of whole words would occur and the sermon would become a confused and meaningless jumble. It therefore became necessary to employ a more rhythmic manner of speaking, to recite or intone.”

-Steen Eiler Ramussen - Experiencing Architecture (1959)

Acoustic space as a medium

- Relation between music and acoustics

  -Hreinn Steingrímsson on Kvæðaskapur in turf houses

  -Hope Bagenal regarding development of music in relation to architecture.

  =>Resonant spaces as the foundation of tonal thoughts/chords?

- Other example – Vocal technique of the opera – large spaces

Comparison of resonances in Churches - http://youtu.be/YVVqNtOsoIo

Resonance

- In physics, resonance is the tendency of a system to oscillate with greater amplitude at some frequencies than at others
- A resonator is a device or system that exhibits resonance or resonant behavior, that is, it naturally oscillates at some frequencies, called its resonant frequencies, with greater amplitude than at others.

Resonance Frequencies

- An acoustically resonant object usually has more than one resonance frequency, especially at harmonics of the strongest resonance. It will easily vibrate at those frequencies, and vibrate less strongly at other frequencies. It will "pick out" its resonance frequency from a complex excitation, such as an impulse or a wideband noise excitation. In effect, it is filtering out all frequencies other than its resonance.

Resonance - Q

The quality factor or Q factor is a dimensionless parameter that describes how “under-damped” an oscillator or resonator is, or equivalently, characterizes a resonator's bandwidth relative to its center frequency.

Higher Q indicates a lower rate of energy loss relative to the stored energy of the oscillator, i.e. the oscillations die out more slowly. Sinusoidally driven resonators having higher Q factors resonate with greater amplitudes (at the resonant frequency) but have a smaller range of frequencies around that frequency for which they resonate; the range of frequencies for which the oscillator resonates is called the bandwidth.

Wikipedia – Q-factor, from the internet 22.04.2012

Link: http://en.wikipedia.org/wiki/Q_factor

Shape of things and resonance

- Thumb rule of resonators is that the simpler the form of it – cylindrical, rectangles, spheres, the higher the Q is on the resonant frequencies (formants)
- It is most often easy to calculate the frequency for the simplers shape - *http://en.wikipedia.org/wiki/Acoustic_resonance*
- Rectangles have multiple resonance frequencies where as standing waves can occur where surface is opposed another surface. See: Room Modes

Alvin Lucier (f. 1931)

- Much of his work is influenced by science and explores the physical properties of sound itself: resonance of spaces, phase interference between closely tuned pitches, and the transmission of sound through physical media
  - *Music for Pure Waves, Bass Drums and Acoustic Pendulums* (1981) – resonance in bass drums
  - *I am sitting in a room* (1969) – a recording re-recorded again and again inside a room. Resonance frequencies appear (similar to a slow [and more controlled] feedback)

Alvin Lucier - Videos

- *Alvin Lucier: I am sitting in a room (1969)* – Performed in 2012 http://youtu.be/TSR2LSuzP_M
- *Alvin Lucier: I am sitting in a room (1969)* – Automated version in 2013 in Hafnarhús http://youtu.be/ZE9xDzVZfz0
- *Alvin Lucier: Music for Pure Waves, Bass Drums and Acoustic Pendulums (1980)* http://youtu.be/SlAGo2e64TY

Thranophones

- First version made in 2007 – under current development since 2011.
- Uses “Larsen-effect”/audio feedback to amplify the resonance frequencies of a given cavity.
- Development of the instrument is documented at

http://thrainnhjalmarsson.info/thranophones

Positive Feedback/Larsen Effect

Audio Feedback is a special kind of positive feedback which occurs when a sound loop exists between an audio input (for example, a microphone or guitar pickup) and an audio output (for example, a loudspeaker). In this example, a signal received by the microphone is amplified and passed out of the loudspeaker. The sound from the loudspeaker can then be received by the microphone again, amplified further, and then passed out through the loudspeaker again. This re-amplification is an example of positive feedback.

The frequency of the resulting sound is determined by resonance frequencies in the microphone, amplifier, and loudspeaker, **the acoustics of the room,** the directional pick-up and emission patterns of the microphone and loudspeaker, and the distance between them.

Wikipedia – Larsen effect, from the internet 22.04.2012

Link: http://en.wikipedia.org/wiki/Larsen_effect

Demonstration of Thranophone #1

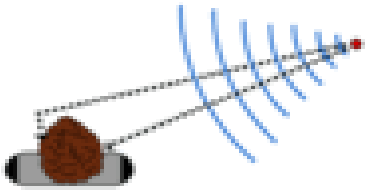
Thranophone #2 – Uses Tuba as the resonant cavity

Physics in relation to spaces

Reverb – sound bouncing of a surface that comes back in the time of 0.1-1 ms

Echo – rebounce of a surface that comes back later than 1ms

Haas effect (or *precedence effect*) delay of the sound is used to position it. Distance between the 2 ears. Used in Wave Field synthesis for example



Projects in the Course

- In a manner to use the knowledge of the engineers, a 3 simple outlines are chosen to work from (or as starting thoughts):
  - 1.Design of a chair in a string instrument – which functions as a filter between the strings and the resonating body of the instrument.
  - 2. Building of a resonance body with a preffered set of frequencies is set.
  - 3. Alternation of a resonant space – a space is chosen and attemps are made to alter it's experience.

Resources

- Steen Eiler Rasmussen, (1959), *Experiencing Architecture.*
- Hreinn Steingrímsson, *Kvæðaskapur*
- Bagenal, Hope. *Influence of building on musical tone*.
- Echo vs. Reverb – Link: http://physicsclassroom.com/mmedia/waves/er.cfm
- **Wikipedia**:
  - Haas effect, from the internet 07.10.2013 - Link: http://en.wikipedia.org/wiki/Precedence_effect
  - Larsen effect, from the internet 22.04.2012 - Link: http://en.wikipedia.org/wiki/Larsen_effect
  - Acoustic Resonance, from the internet 07.10.2013 – Link: http://en.wikipedia.org/wiki/Acoustic_resonance'
  - Q-factor - Link: http://en.wikipedia.org/wiki/Q_factor
  - Resonator – Link: http://en.wikipedia.org/wiki/Resonator