

ECS614U/ECS749P: Sound Recording and Production

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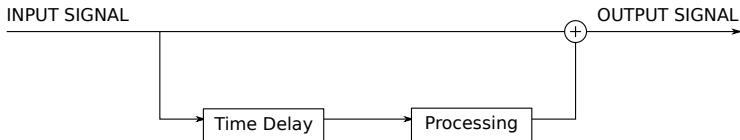
Mixing: Delay

Introduction

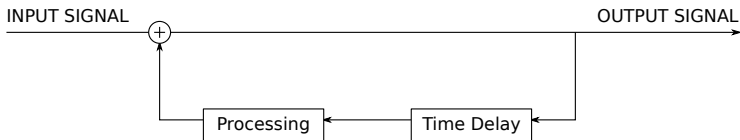
- Delay based effects send copies of the original signal to which a time delay and various other processing has been applied.
- Delay based effects have a number of uses.
 - As tools to add interest to a song, e.g. echo, chorus, flanger.
 - As equalisation filters.
 - To simulate room acoustic effects, e.g. reverberation.

Delay loops

FORWARD LOOP

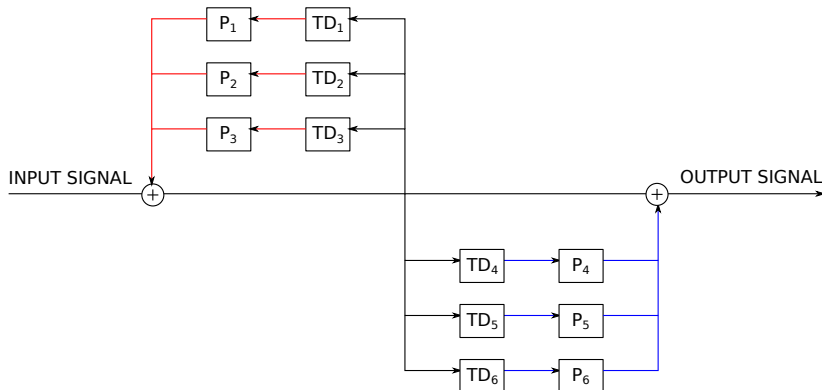


FEEDBACK LOOP



Delay cascade

- A typical delay effect will contain a cascade of delay paths, and both forward and feedback sections.



Echo / Flanger / Chorus

Echo

- A single forward delay loop, with a delay time long enough for delayed version to be perceived as separate sounds, i.e. as echoes.
- A feedback loop may be added to sustain the echo.
- The delayed versions can be processed to change their, e.g. gain, equalisation etc.
- More complex delay effects combine multiple echoes.

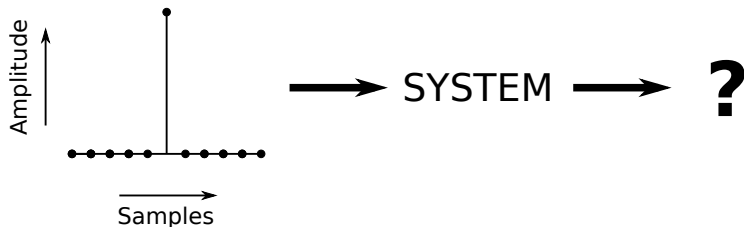
Phasor, Flanger and Chorus

- A single forward loop, with a delay time is short enough for original and delayed versions to be perceived as one entity, i.e. deliberate comb filter!
- Parameters of the processor are varied using an oscillator.
- **Phasor**: alters the phase of delayed version.
- **Flanger**: applies very short delay time, e.g. 20 ms (commonly used on guitars).
- **Chorus**: applies slightly longer delay compared to flanger (used to simulate choir effect).

Impulse Response

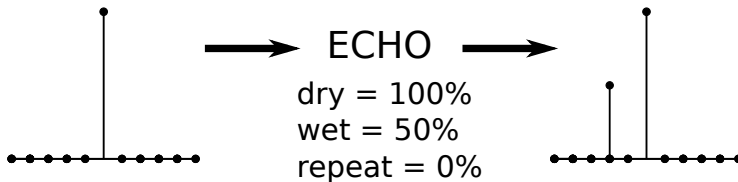
System Impulse Response

- If I send an impulse into my system, what will be output?



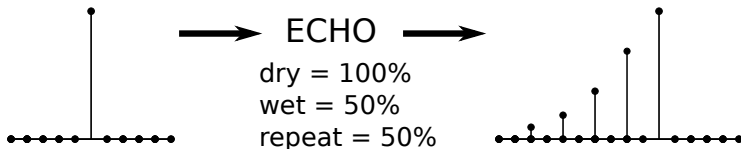
Echo Impulse Response

- With only a forward loop there are a finite number of pulses in the impulse response.



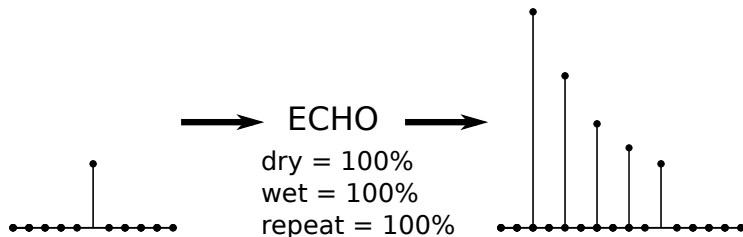
Echo Impulse Response

- With a feedback loop there will be an infinite number of pulses in the impulse response.



Echo Impulse Response

- If the gain of the feedback loop is too high the impulse response will grow uncontrollably - it is unstable.



Impulse Response

- The impulse response is the time-domain representation of the frequency response. Algorithms can be use to switch between the two representations (Fourier analysis).
- A system with only forward loops has a **finite** impulse response.
- A system that includes feedback loops has an **infinite** impulse response, and has the potential to be unstable.

Equalisation

Digital Equalisers

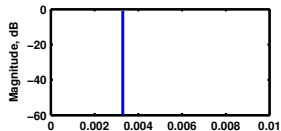
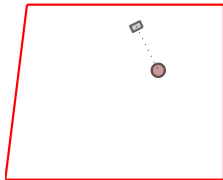
- Digital equalisers are constructed using delay networks with very short delay times, and are referred to as filters.
 - Feedforward only: **F**inite **I**mpulse **R**esponse filter.
 - Feedforward and feedback: **I**nfinite **I**mpulse **R**esponse filter.
- **FIR** filters generally have more delay paths and have a less ideal response.
- **IIR** filters can be unstable, and cause more extreme phase changes to the sound.
- Parametric equalisers (e.g. those in Logic) are **IIR** filters with two feedforward and two feedback loops.

Reverberation

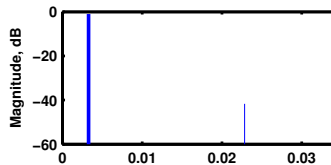
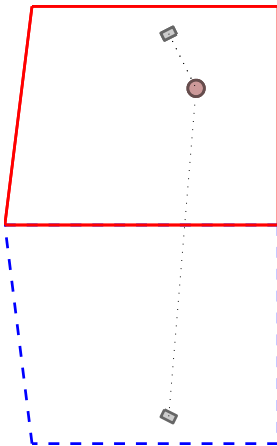
Delay Networks for Reverberation

- How can we describe the signal path from loudspeakers to the listener, including the effect of reflections?

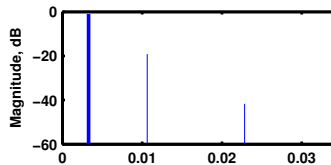
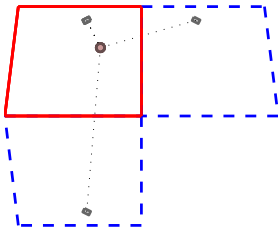
Room Reflections



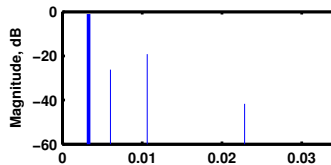
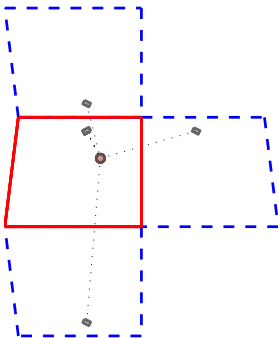
Room Reflections



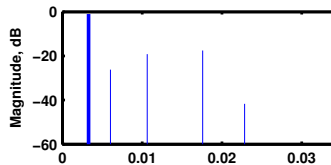
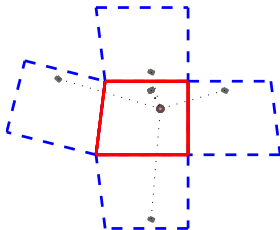
Room Reflections



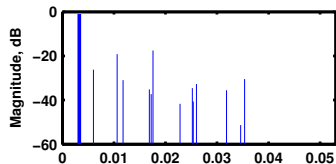
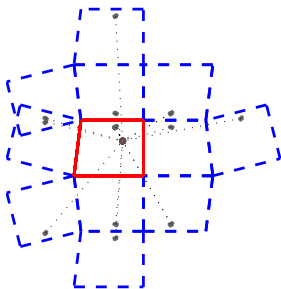
Room Reflections



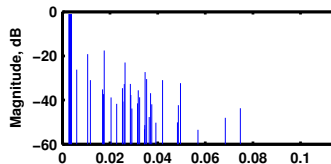
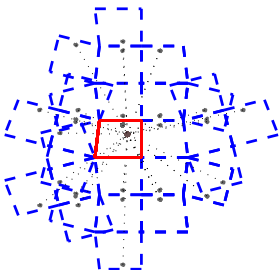
Room Reflections



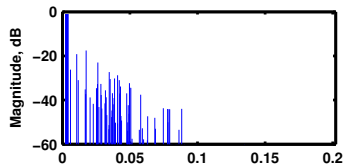
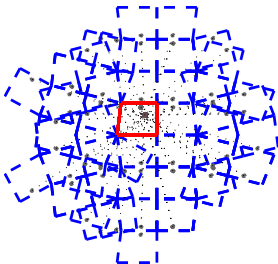
Room Reflections



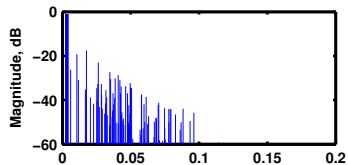
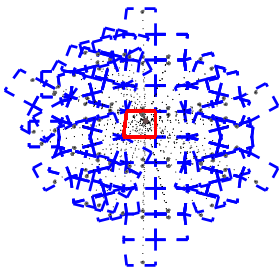
Room Reflections



Room Reflections

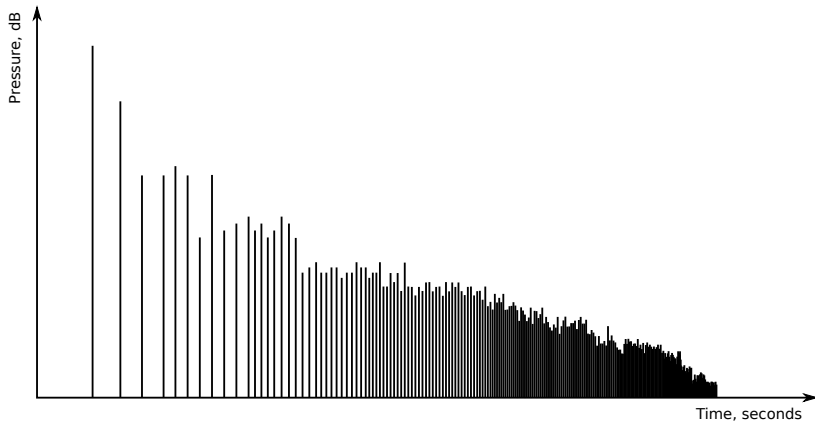


Room Reflections



Room Impulse Response

If my source produces an impulse, what does my receiver measure?



Delay Networks for Reverberation

- There are two classes of reverberation effect.
 - Artificial reverb.
 - Convolution reverb.
- In both types, each delayed copy of the input signal represents a reflection.

Artificial reverb

- Artificial reverberators use feedforward **and feedback** delay networks to simulate room reverberation.
- Artificial reverberators do not attempt to replicate the sound of a specific space.
- The delay networks can be tuned using multiple parameters to get the desired sound.
- High end artificial reverberator plugins are **very** expensive.

Convolution reverb

- Convolution reverberators use **only feedforward** delay networks to simulate room reverberation.
- The impulse response is a representation of the sound in a real or virtual space.
- Each point in the RIR has a delay, gain and polarity, so very large cascades of **forward** delay loops are needed.
- The calculation process (convolution) has been optimised. It is performed in the frequency domain to improve efficiency but they are still processor intensive.

Spatialisation using reverberation

- Our sense of space and position of sources is highly dependent on reverberation.
- The amount of reverberation can convey distance, and using stereo impulse responses alongside panning can give a convincing impression of source position.
- More convincing impressions of space can be achieved by using a 3D sound field. This can be done fairly easily for playback on headphones if you have some HRTFs handy.

HRTFs

- HRTF stands for **H**ead **R**elated **T**ransfer **F**unction.
- It is analogous to a room impulse response:
 - A room impulse response describes how the sound waves travel from a source to a microphone within a space.
 - An HRTF describes how the sound travels from the space around you, and into your ears.
- You can get exceptionally good impressions of space using this approach.

Impulse response measurement

- How do we measure a room impulse response?
 - Play a test tone through a loudspeaker, e.g. noise or sine-sweep, that contains all frequencies of interest.
 - Record the signal at a location within the room.
 - Compare the original signal with the recorded signal.
 - ...or the old fashioned way → make an impulsive sound and record it!
- You can do this in any space and then super-impose the measured response onto any future recording.