

ECS614U/ECS749P: Sound Recording and Production

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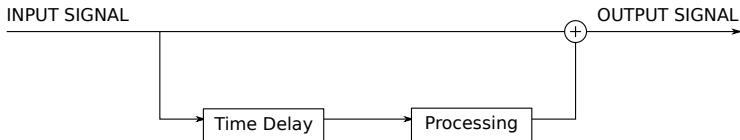
Mixing: Delay

Introduction

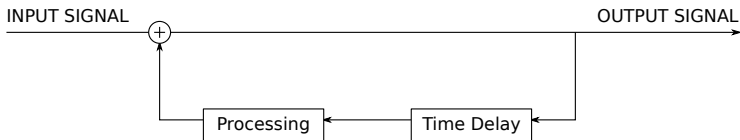
- Delay based effects send copies of the original signal to which a time delay and various other processing has been applied.
- Delay based effects have a number of uses.
 - As equalisation filters.
 - As tools to add interest to a song, e.g. echo, chorus, flanger.
 - To simulate room acoustic effects,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

Delay loops

FORWARD LOOP

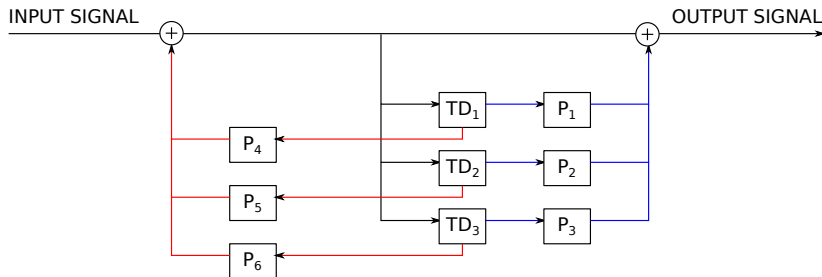


FEEDBACK LOOP



Delay cascade

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



Equalisation

Digital Equalisation Filter

- Digital equalisation filters are either:
 - 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.
- **IIR** filters can be unstable (e.g. like acoustic feedback).
- Parametric EQs tend to use **IIR** filters.

Low Pass FIR Filter

Low Pass IIR Filter

Very short delay

Echo / Flanger / Chorus

Echo

- Delay time is long enough for delayed versions to be perceived as separate sounds.
- Can have feedback to sustain echo.
- Can process delayed versions to change its properties, e.g. gain, equalisation etc.

Flanger and Chorus

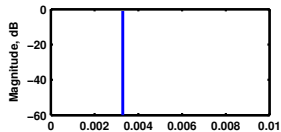
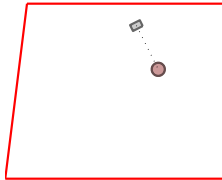
- Delay time is short enough for sounds to be perceived as once entity, i.e. deliberate comb filter!
- Flanger has static delay time.
- Chorus has a varying delay time, e.g. driven by oscillator.

Reverberation

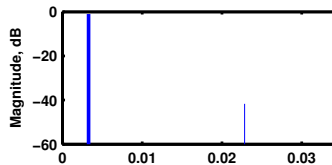
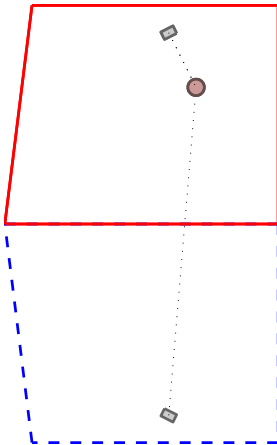
Delay Networks for Reverberation

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

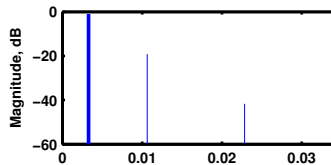
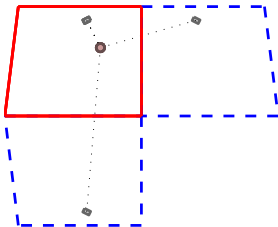
Room Reflections



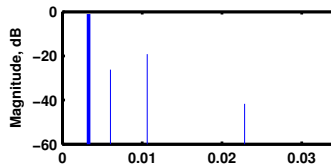
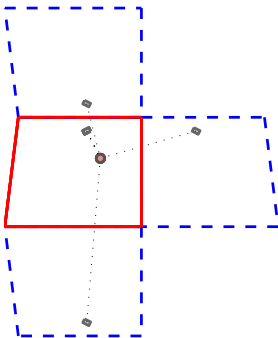
Room Reflections



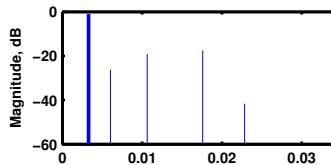
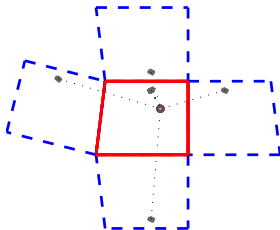
Room Reflections



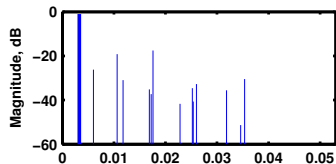
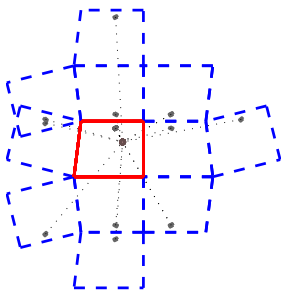
Room Reflections



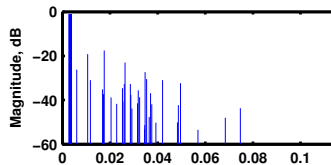
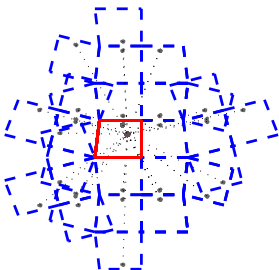
Room Reflections



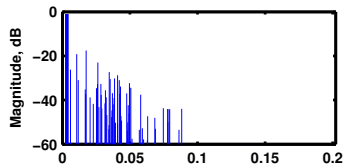
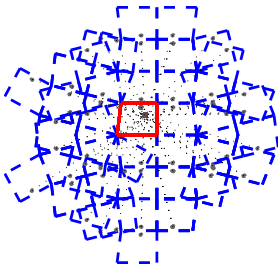
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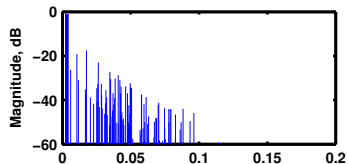
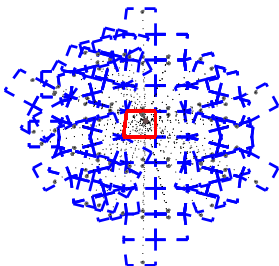
Room Reflections



Room Reflections

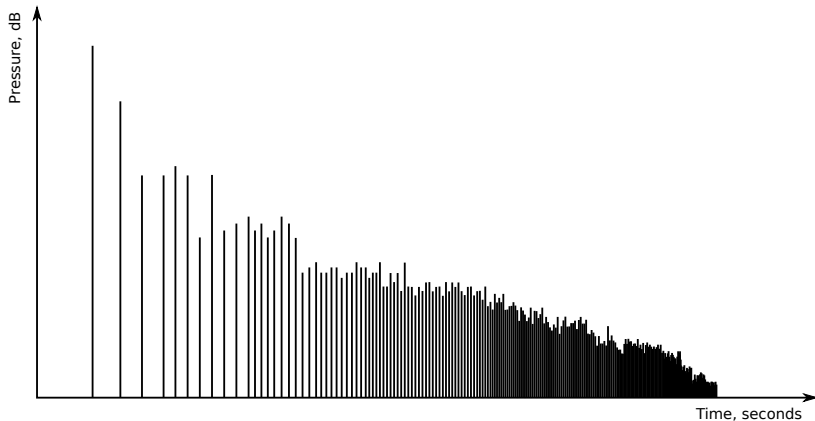


Room Reflections



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 is 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 an impulse response:
 - An 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.
- You can do this in any space and then super-impose the measured response onto any future recording.

Flanger/Chorus/Phasor