



# INTRODUCTION TO COMPUTER MUSIC SAMPLING SYNTHESIS AND FILTERS

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# SAMPLING SYNTHESIS

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Synthesis from pre-recorded sounds

## Sampling Synthesis



- FM and other techniques were “big” when computation and memory were expensive.
- But FM never produced satisfactory simulations of acoustic instruments.
- Sampling is a simple concept:  
Record actual sounds and play them back!
- Advantages:
  - Easily captured sounds
  - Works with noise, tones, anything

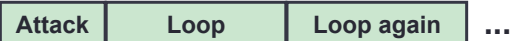
## How it works



- Base case: store a sound and play it back
- Desired parameters:
  - Duration
  - Pitch
  - Amplitude
  - Vibrato
  - Brightness

## Controlling Duration

- Repeat a portion of sound
  - Could be a single period
  - Could be much longer segment
  - Finding good “loop points” is tricky
- Use an envelope and multiply to decay at end

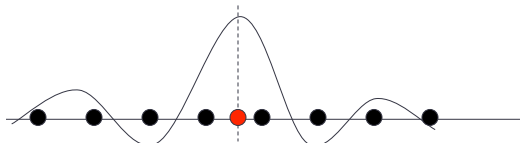


## Finding Loop Points

- Often done "by ear" interactively
- Tones are not often truly periodic
  - changes in amplitude, frequency, noise, spectrum
  - but you can pick where to start looping (a search problem)
  - you can cross-fade to make a smoother transition
- Periods are not always integer number of samples
  - At  $G_4$  (391.995 Hz), 1 period =  $44100/f_0 = 112.501$  samples
    - Upper harmonics are of course much shorter, so cutting out even half a sample is significant.
  - You can loop over multiple periods.
  - You can resample (interpolate) to get an integral length

## Controlling Pitch

- Resample to speed up and slow down
- Usually over limited range (2 to 12 semitones)
- Linear interpolation can cause aliasing
- Good samplers use multipoint interpolation using a weighted sum; number of points is considered trade secret



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## Controlling Amplitude

- Simple multiply
- Or, cross-fade between loud/soft samples
  - Cross-fades risk phase cancellation
- Can apply low-pass filter to make softer sounds less bright

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## Other Parameters, Modifications

- Filters for various effects
- Frequency and Amplitude vibrato is easy to add
- Reverb, chorus, other effects
- Starting sample at offsets to emphasize/deemphasize attack transients
- Notice that these are all *synthesis* techniques

## Problems with Sampling Synthesis

- Most of the interesting sound quality is “frozen” in the samples
- Strings and woodwinds are controlled by bowing and blowing, not so much by the passage of time – bad model
- Samples can take lots of space: modern libraries take gigabytes

# Examples

- See `sampling.sal`

