

MUS420/EE367A Lecture 5C  
Commutated Synthesis of Strings

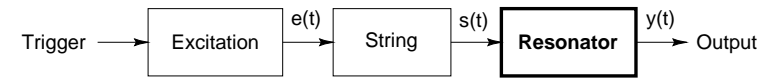
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## Outline

- Basic Idea
- Body Resonator Factoring
  - Shortened Body Impulse Response
  - Corresponding Amplitude Response
  - Localized Second-Order Mode Elimination Filter
- Commuted Piano Synthesis
  - String Interface
  - Excitation Factoring
- Linear Commuted Violin Synthesis

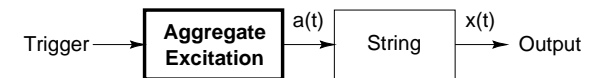
## Commutated Synthesis of Strings



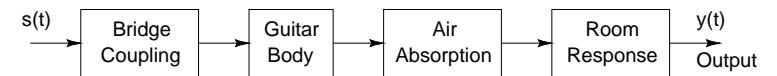
Schematic diagram of a stringed musical instrument.



Equivalent diagram in the linear, time-invariant case.



Use of an aggregate excitation given by the convolution of original excitation with the resonator impulse response.



Possible components of a guitar resonator.

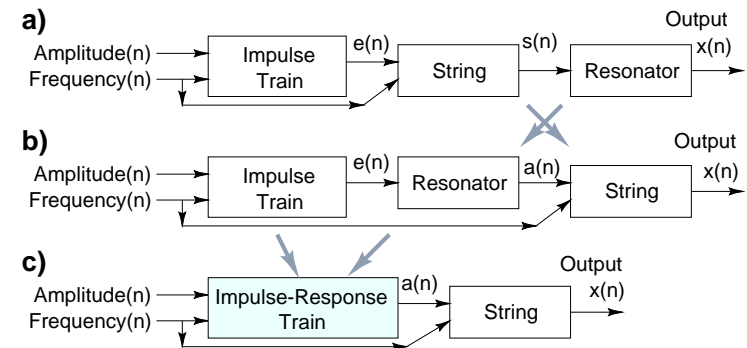
## Features of Commuted Synthesis

- Enormous resonators can be implemented inexpensively (three orders of magnitude less computation for typical stringed instruments)
- Good qualitative excitation signals are easy to measure (just tap on the bridge)
- Apparent “resonator size” can be modulated by changing the *playback rate* of the excitation table

### Drawbacks:

- Requires *linearity* and *time invariance*

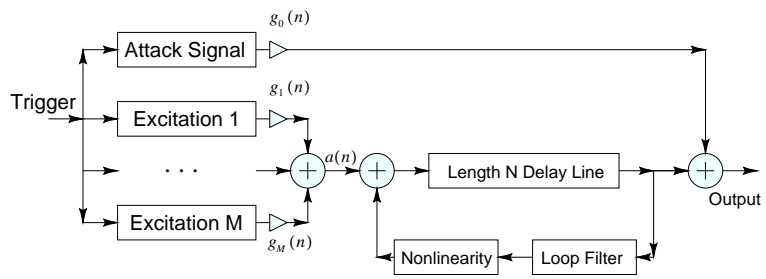
## Linear Commuted Violin Synthesis



- Assumes *ideal Helmholtz motion*
- Sound examples:

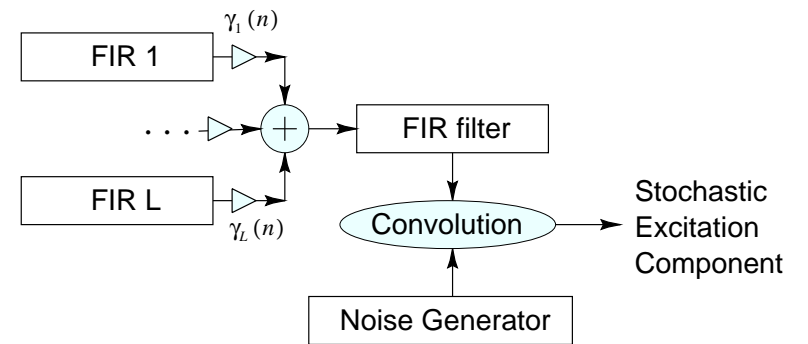
<http://ccrma.stanford.edu/~jos/wav/vln-lin-cs.wav>

## Multiple-Excitation Commuted Synthesis



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## Filtered-Noise Excitation Synthesis



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## Commuted Synthesis of the Linearized Violin

