Outline

• Basic Idea
• Commuted Piano Synthesis
  – String Interface
  – Excitation Factoring
• Linear Commuted Violin Synthesis

Commuted 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:

  [Link to sound example](http://ccrma.stanford.edu/~jos/wav/vln-lin-cs.wav)
Multiple-Excitation Commuted Synthesis

- For pianos, harpsichords, etc.,
  - Excitation point moves with key number
  - Wavetable interpolation can be used as in sampling synthesis
- For guitars, violins, cellos, etc.
  - Each string has a slightly different excitation point
  - Vertical and horizontal excitations different
- “Attack Signal” = sound going “around” the strings (or only once through the string)

Energy Decay Relief (EDR) of a Violin Body
Impulse Response

- Energy summed over frequency within each “critical band of hearing” (Bark band)
- Low-frequency modes “resolved”
- High-frequency modes merge together perceptually into a
Filtered-Noise Excitation Synthesis

FIR 1

\[ \gamma_1(n) \]

\[ \ldots \]

FIR filter

FIR L

\[ \gamma_L(n) \]

Stochastic Excitation Component

Noise Generator

Convolution