

Real-time finite-difference string-bow interaction FPGA model coupled to a violin body

Florian Pfeifle / Rolf Bader

Musicological Institute
University of Hamburg

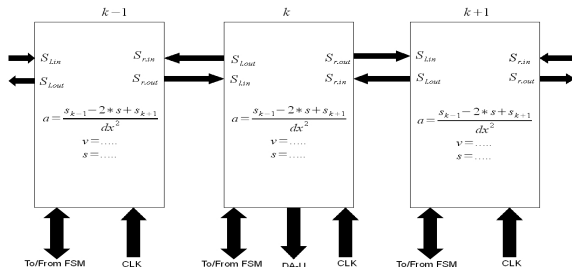
3. November 2011 / 162. ASA Meeting in San Diego

Overview

- 1 Introduction
 - Prior work
 - String-bow model
- 2 Extension of the model
 - Playable violin
 - Final model

Finite Differences on a FPGA

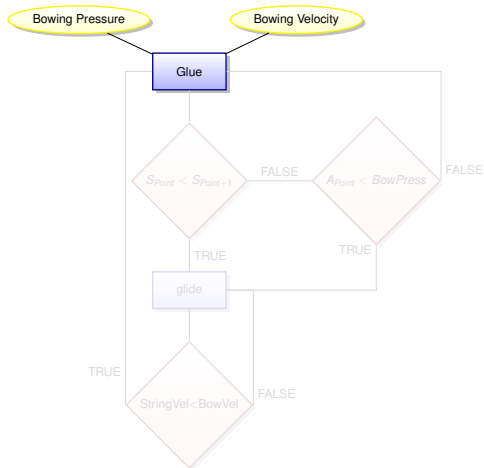
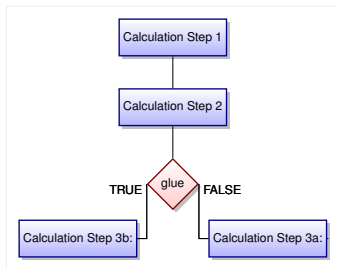
- Real-time Finite Differences solver for several instrument geometries
 - Banjo, Ruan, Tanbur
- Models are playable in Realtime
 - Xilinx Virtex-6 FPGA via PCI-Express
 - Controllable from software



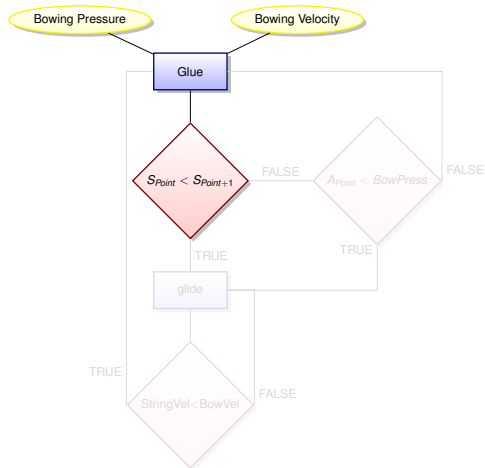
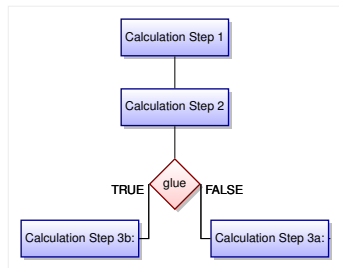
String-bow model

- Based on a stick-slip model
- Playing parameters are bow-pressure (BP), bow-velocity (BV)

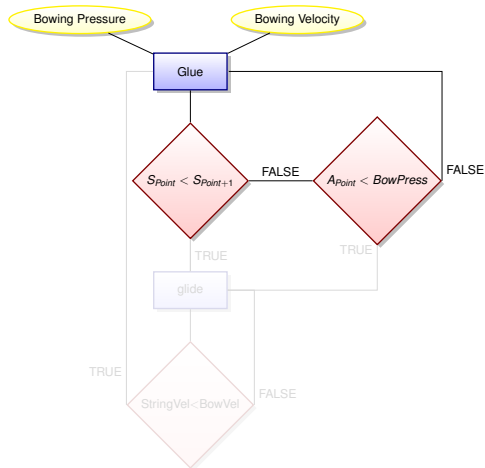
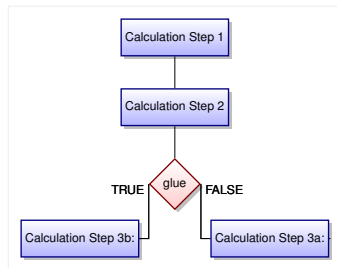
Stick-slip model 1



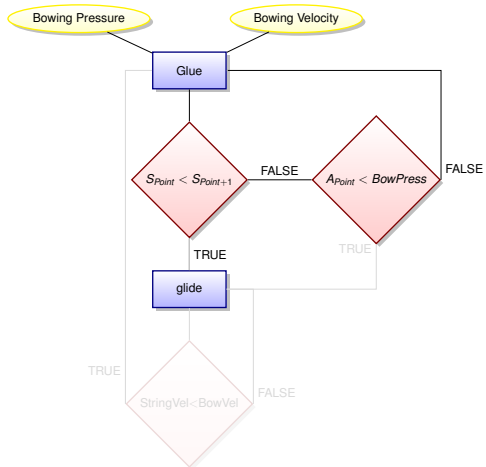
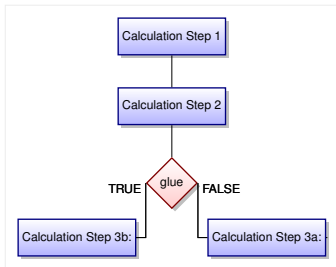
Stick-slip model 1



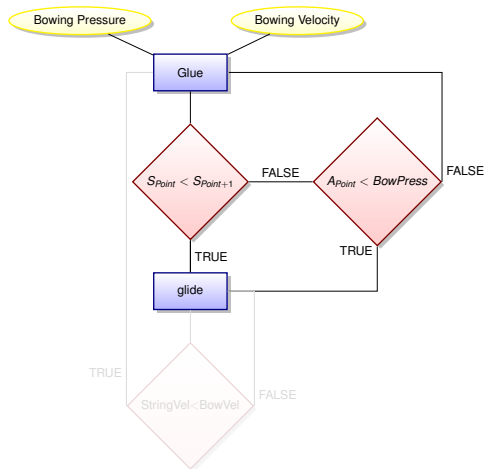
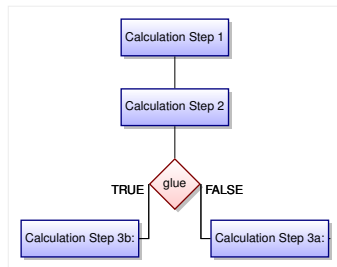
Stick-slip model 1



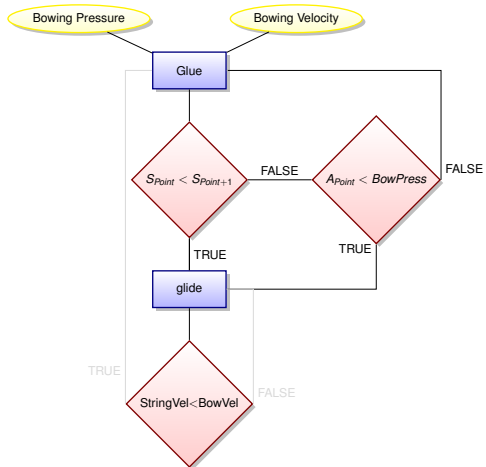
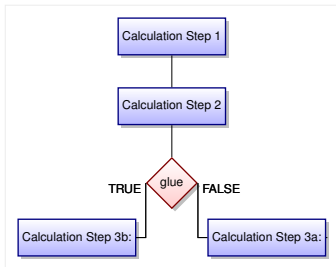
Stick-slip model 1



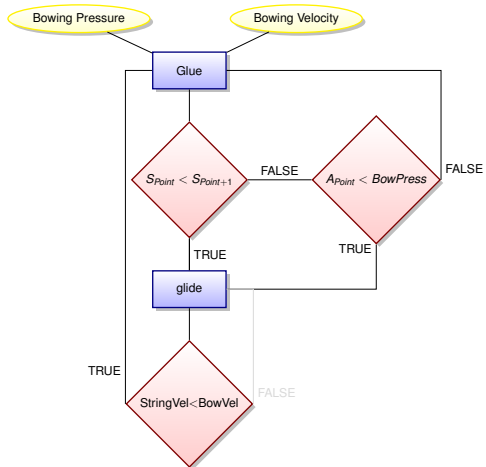
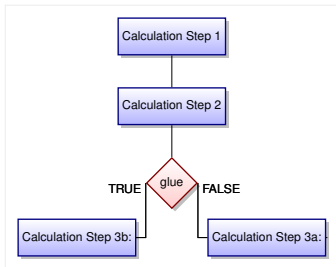
Stick-slip model 1



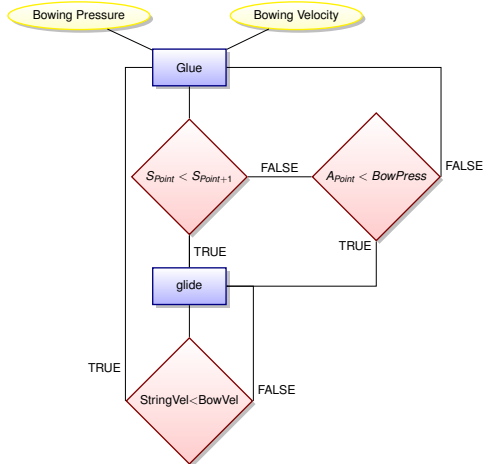
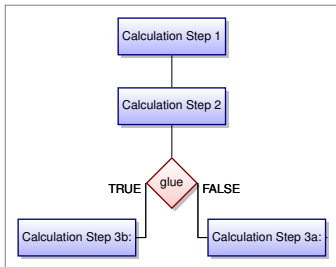
Stick-slip model 1



Stick-slip model 1



Stick-slip model 1



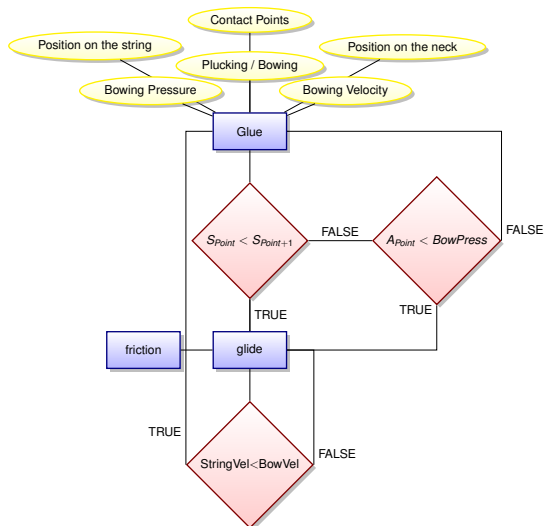
Stick-slip model 2

- Calculation Step 3a: (Slipping)
 - Calculating normal string movement
- Calculation Step 3b: (Sticking)
 - At the bowing point \Rightarrow string-velocity = bow-velocity
- \Rightarrow Sound
 - Stable bowing
 - Jump to first partial
 - High note with vibrato
 - Subharmonics
 - Real violin, bow machine

Additional parameters for the string

- Position of the bow \Rightarrow change in the harmonic spectrum
- Position of the finger on the neck \Rightarrow additional damping
- The length of the string (Tuning)
- Bow on/off
- Plucking / bowing the string
- One, two or three contact points of the bow

Stick-slip model 2



Stick-slip model 2

- Calculation Step 3a: (Slipping)
 - Calculating normal string movement
 - Additional damping at bow-point: kinetic friction (depending on the velocity)
- Calculation Step 3b: (Sticking)
 - At bowing point \Rightarrow string-velocity = string-velocity + bow-velocity
 - At bowing point \Rightarrow string-acceleration is influenced by bow-pressure
- \Rightarrow Sounds:
 - Stable bowing
 - Stable bowing high
 - High pressure, slowing down
 - Scale

Additional modifications

- Position of the bow
- Plucking
- Fretted string → higher damping
 - High velocity damping at finger-string interaction point ⇒ no frets

- ⇒ Sounds:
 - The final model includes:
 - String, bridge violin body and air
 - Whole geometry several points on front plate
 - Changing thickness of front plate while playing
- Further work
 - Implement a midi interface
 - Implement gesture data (Force, velocity and position)

Discussion

- Thank you...
- Questions...?