Modeling South Asian and Chinese Instruments in GeoShred

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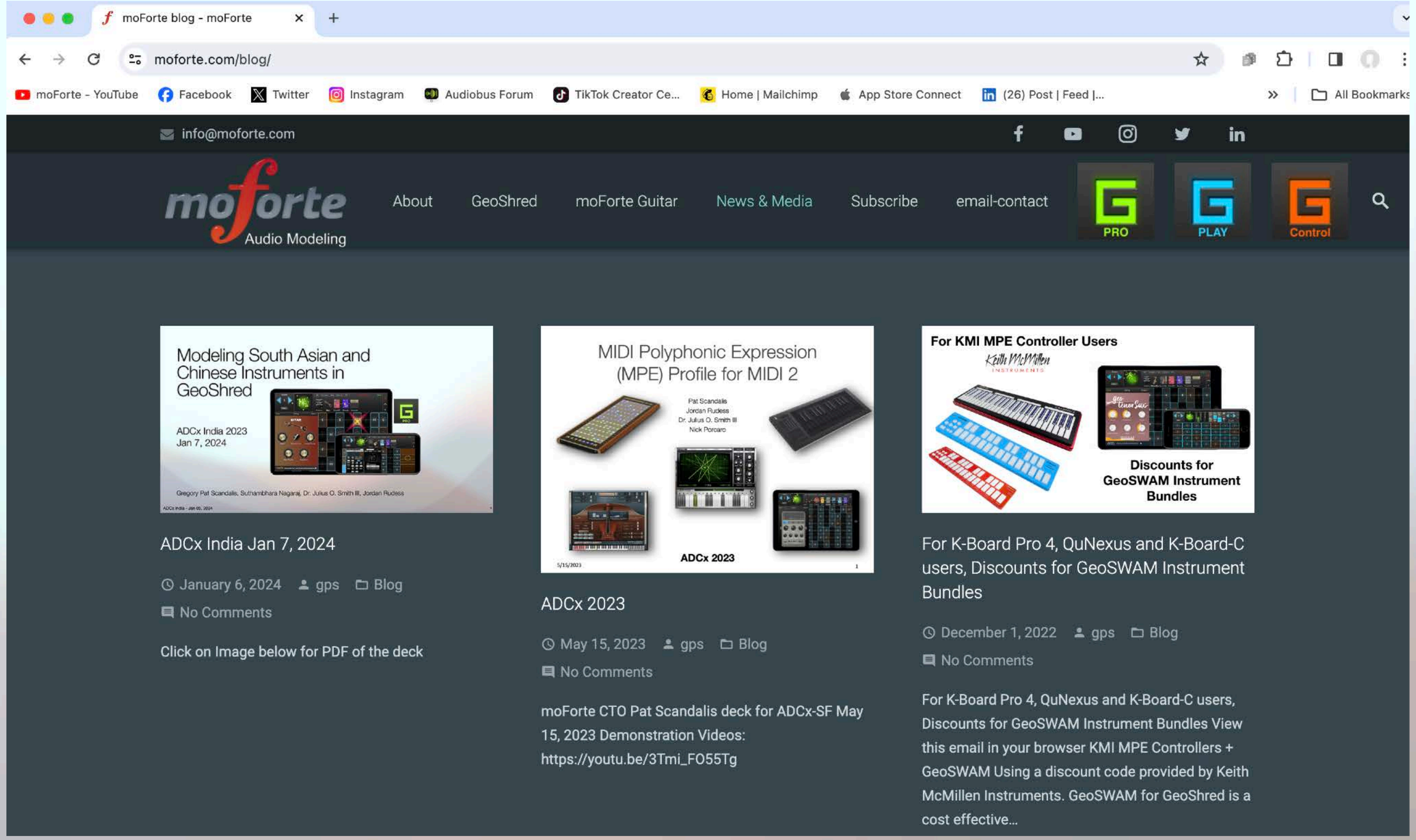
Outline of Topics

- Let’s start with Demonstrations!
- A Brief History of Physical Modeling Synthesis
- MPE MIDI and Modeling
- Special Modeling Considerations for South Asian and Chinese Instruments
- Questions

This Presentation Can be Found at:

http://www.moforte.com/news



Physical Modeling Collaborators

wizdom music

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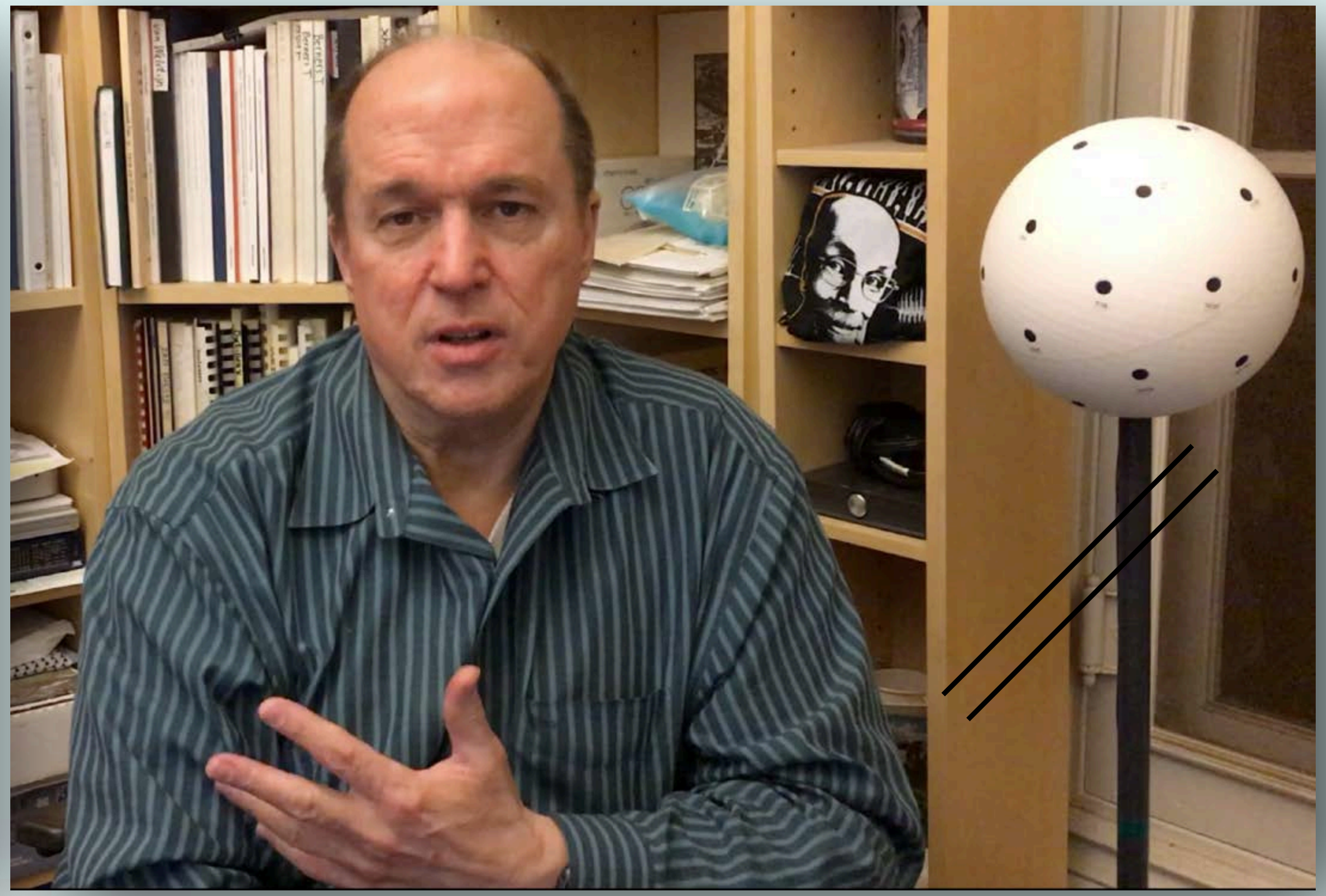
Audio Modeling



Audio Modeling

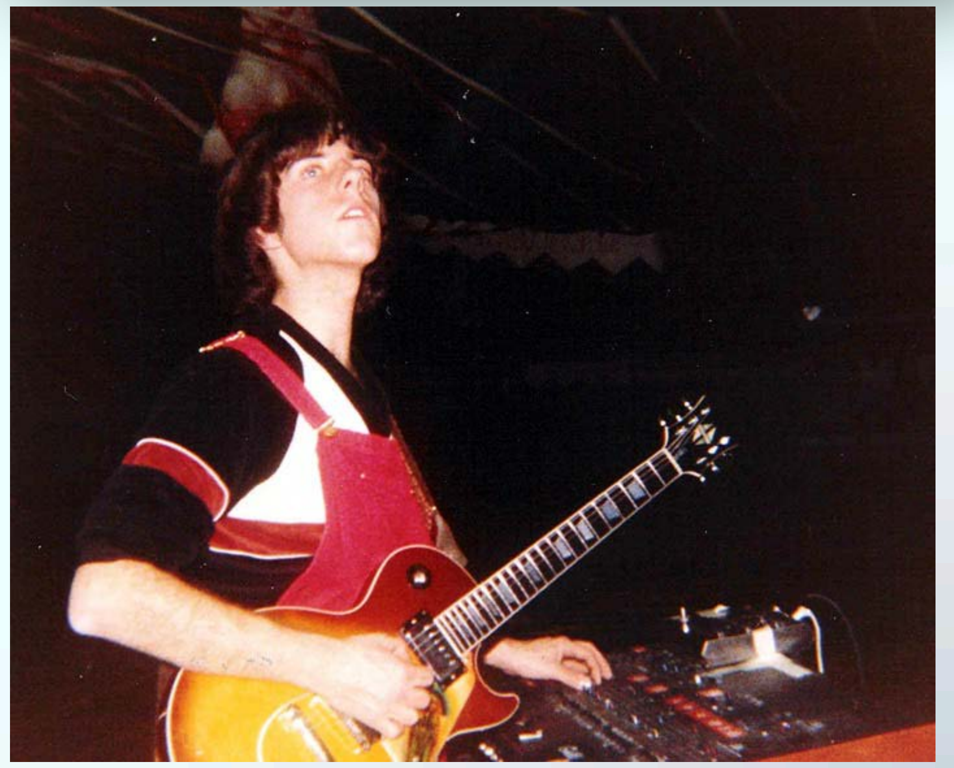
GeoShred is a collaboration between Rock Star and mobile music innovator Jordan Rudess, Stanford/CCRMA Professor Dr. Julius O. Smith III, Nick Porcaro, Pat Scandalis

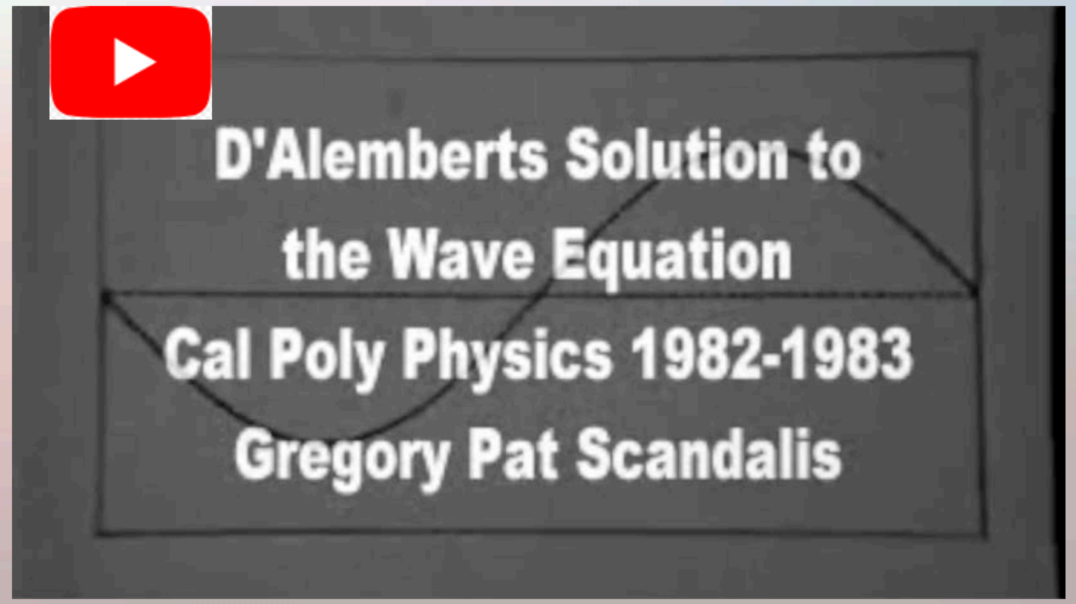
Additional models developed by Audio Modeling/ SWAM (Stefano Lucato, Lele Parravicini) and AccelMatrix/Naada (Suthambhara Nagaraj)

naada

About Pat

- 40 years in the Silicon Valley as an Engineer
- Built my first monophonic electronic instrument from a Radio Shack kit in 1970
- Gigged with an Arp Avatar guitar synth (1978)
- Computer modeling of vibrating strings and membranes for senior thesis in Physics (1982)
- Researcher in Physical Modeling at Stanford/CCRMA (1994)
- CEO/CTO of moForte
  Chairman of the MPE Subcommittee MIDI Association





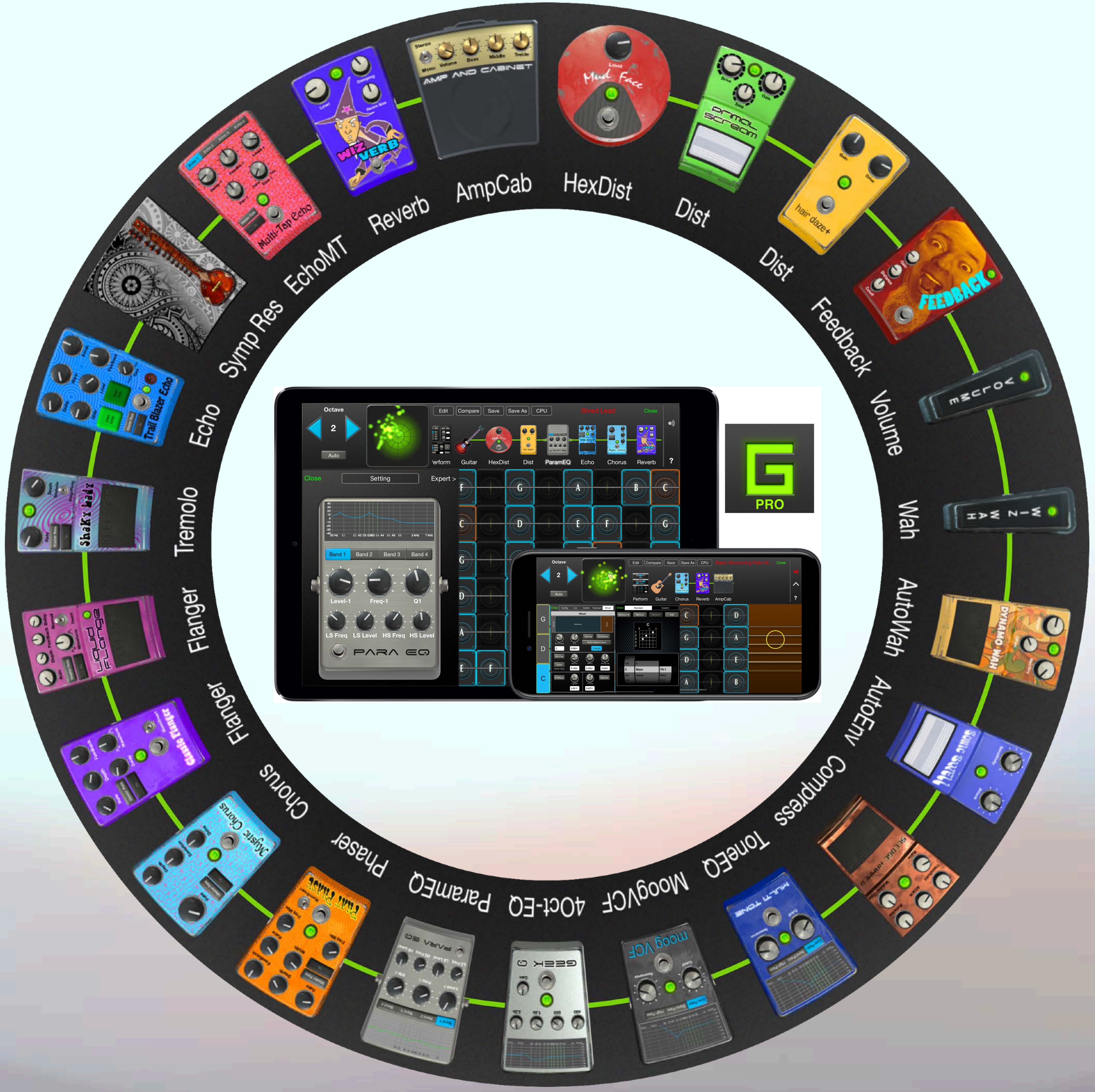
CCRMA

A Few Brief Performances

What is GeoShred (brief)?

A Framework for Modeled Instruments and Effects

Currently 22 Modeled Effects




Octave
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DISCOVER ALL THE NAADA INSTRUMENTS
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2
Auto
Edit
Compare
Save
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Guitar
Chorus
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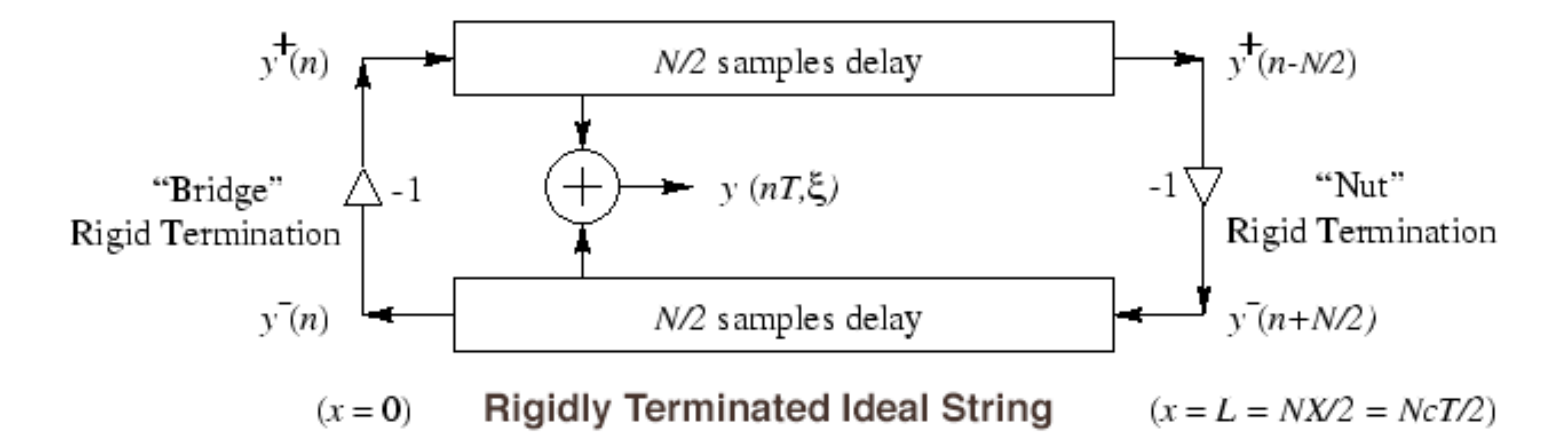
PRO

Currently 33 Physically Modeled Instruments

A Brief History of Physical Modeling Synthesis



What is Physical Modeling Synthesis?

- Methods in which a sound is generated using a mathematical model of the physical source of sound.
- Any gestures that are used to interact with a real physical system can be mapped to parameters yielded an interactive and expressive performance experience.
- **Physical modeling is a collection of different techniques specific to each sound generation process.**

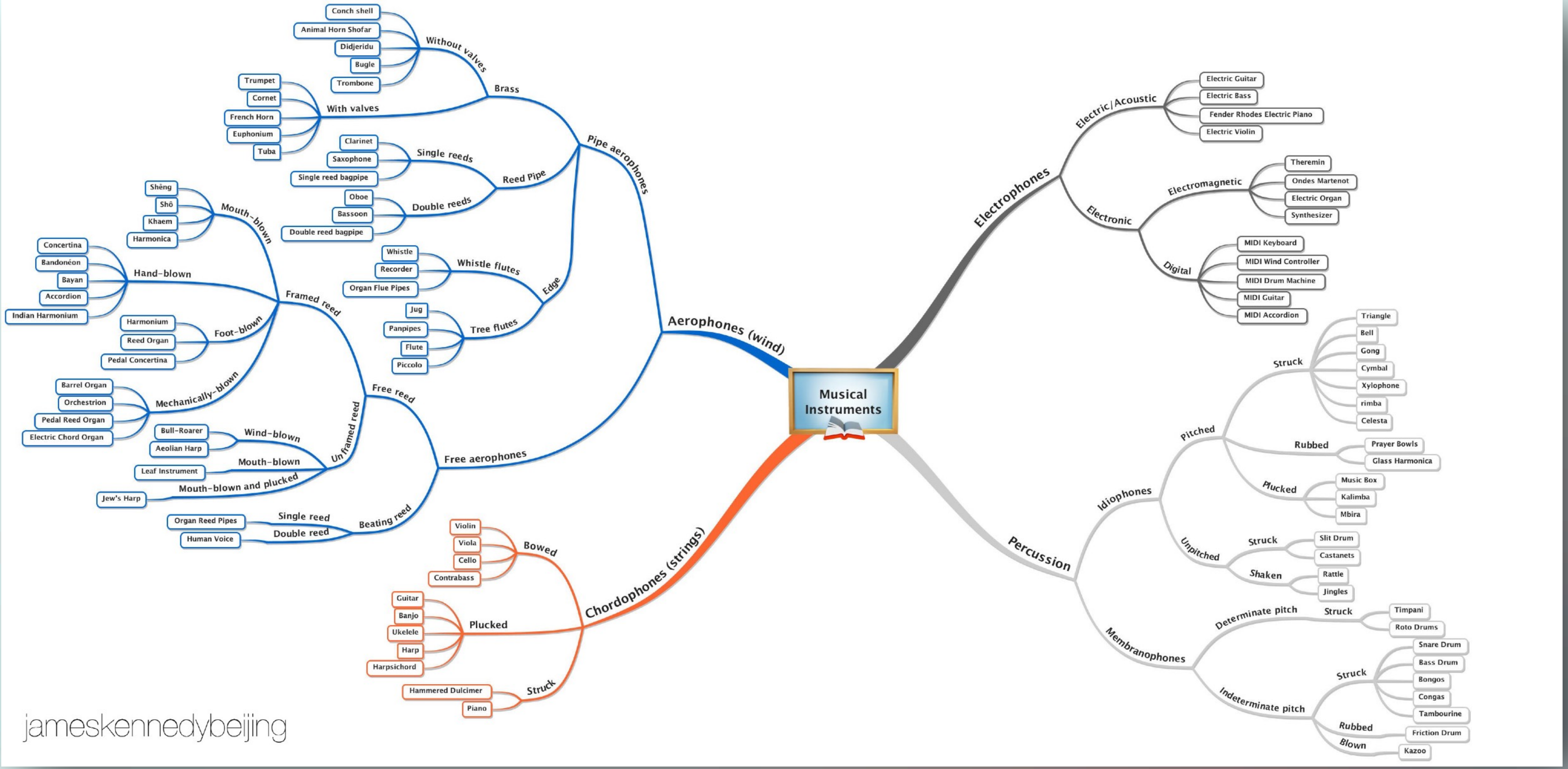
$$\frac{\partial^2 y}{\partial t^2} = \frac{1}{v_w^2}\frac{\partial^2 y}{dt^2}$$

Physics + Math

物理 + 數學

Taxonomy of Modeling Areas

Hornbostel–Sachs Classification



- Chordaphones - Guitars
- Aerophones - Woodwinds
- Membranophones - Drums
- Idiophones - Mallet Instruments
- Electrophones - Virtual Analog
- Game Sounds
- Voice

The Voder (1937-39) - Homer Dudley

- Analog Electronic Speech Synthesis
- Analog model of the vocal tract
- Develop from research on voice compression at Bell Labs.
- Featured at the 1939 Worlds fair

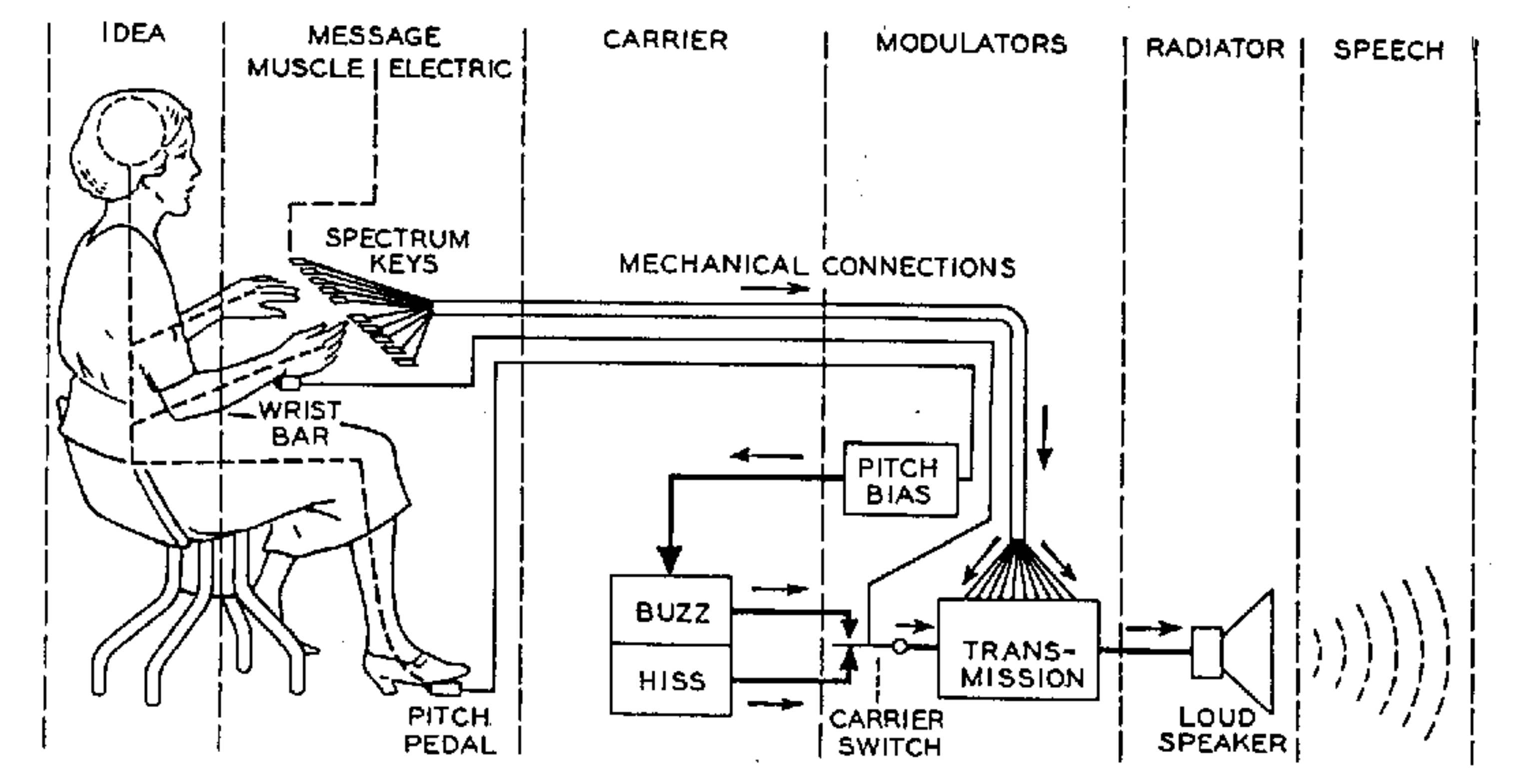
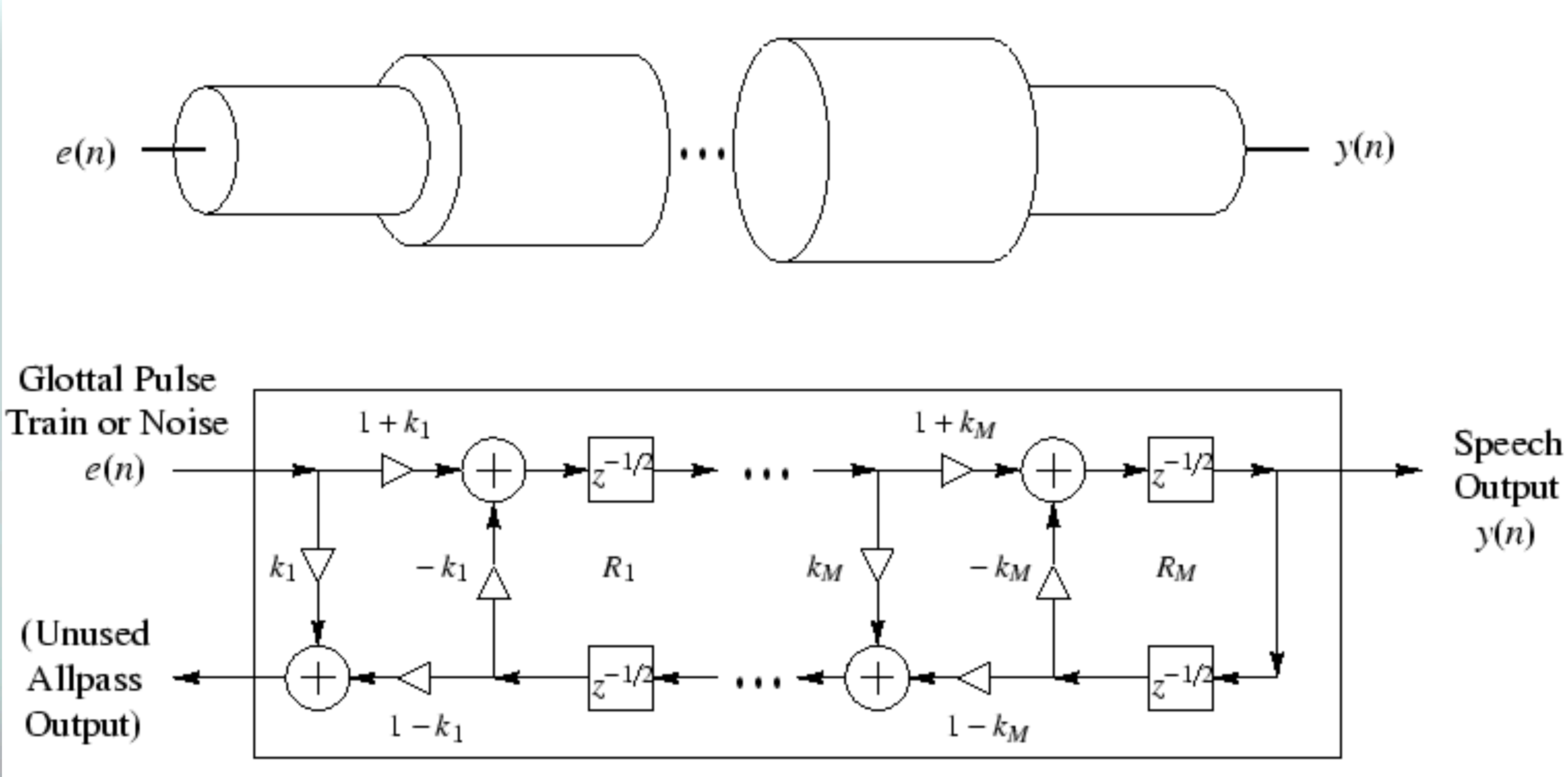


Fig. 8—Schematic circuit of the voder.


The Voder as demonstrated by Mrs. Harper at The Franklin Institute.

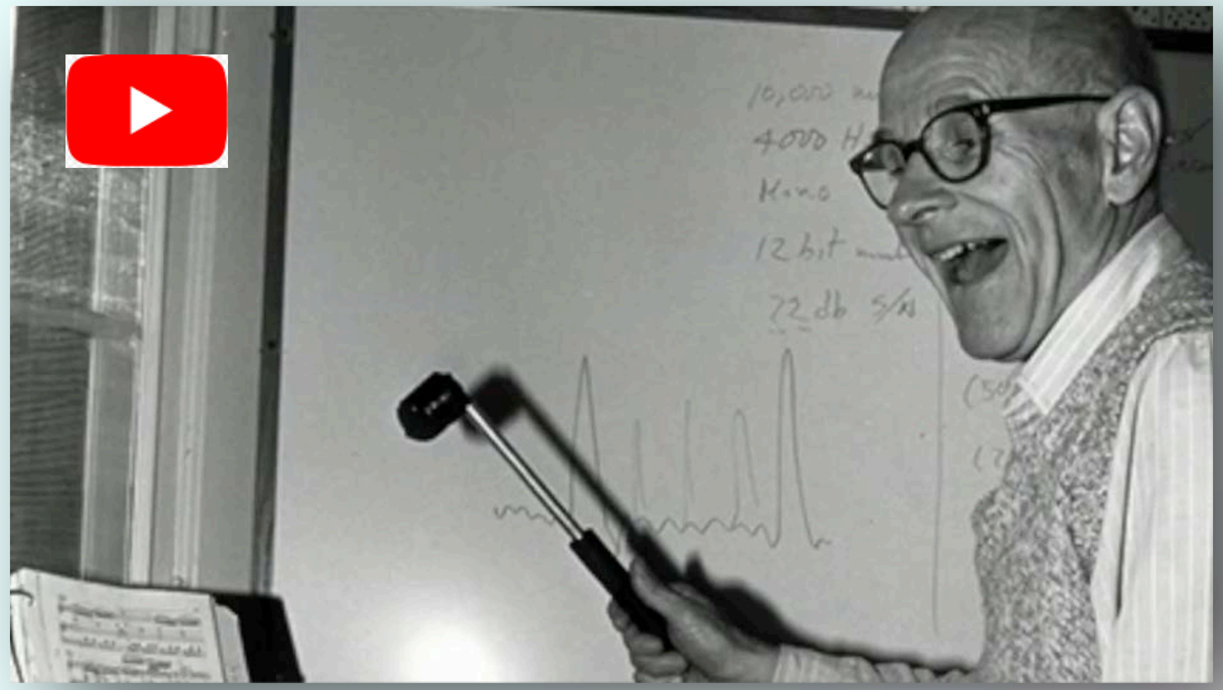
Kelly-Lochbaum Vocal Tract Model (1961)

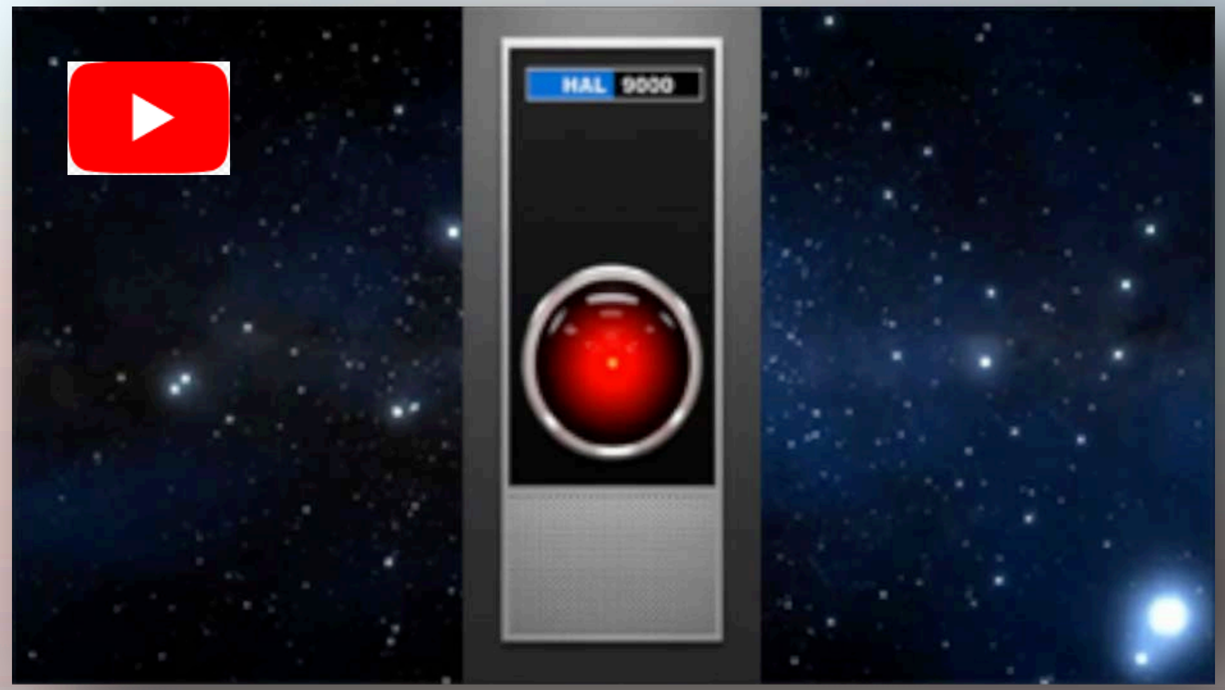


Kelly-Lochbaum Vocal Tract Model (Piecewise Cylindrical)

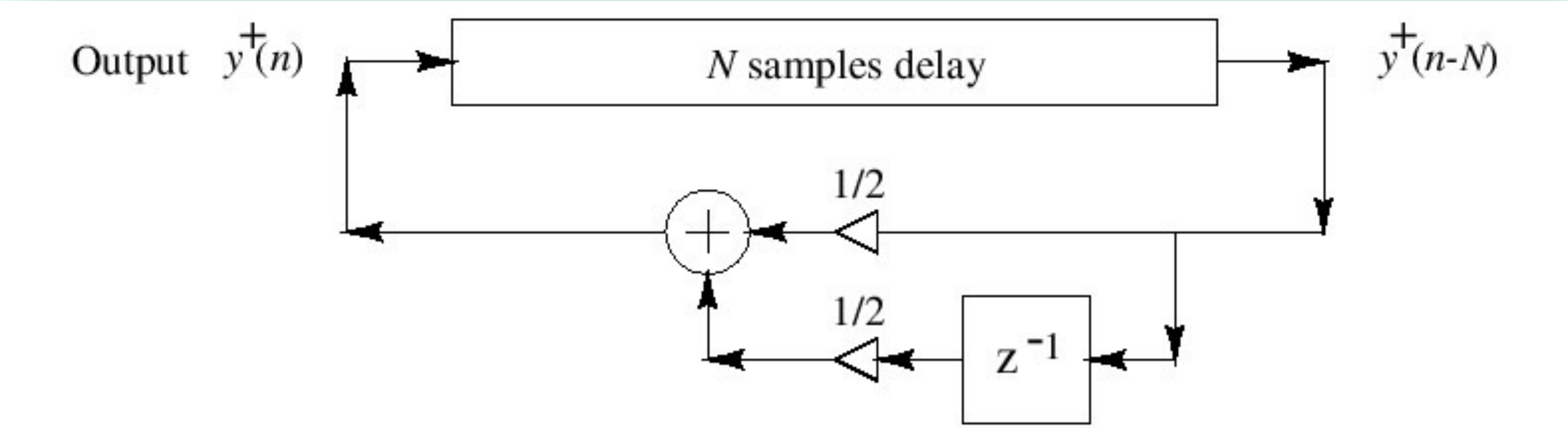
Daisy Bell (1961)

- Daisy Bell
- Vocal part by Kelly and Lochbaum (1961)
- Musical accompaniment by Max Mathews
- Computed on an IBM 704
- Based on Russian speech-vowel data from Gunnar Fant's book
- Probably the first digital physical-modeling synthesis sound example by any method
- Inspired Arthur C. Clarke to adapt it for "2001: A Space Odyssey" the Hal 9000's "first song"



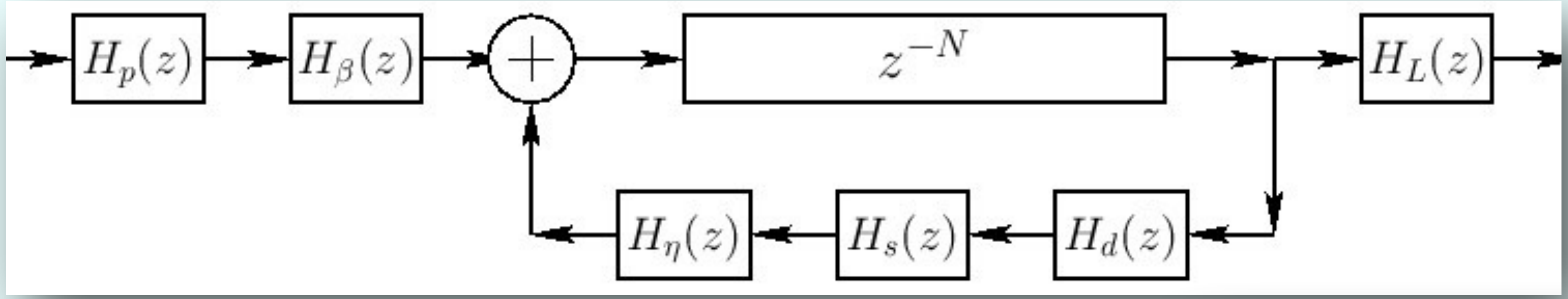


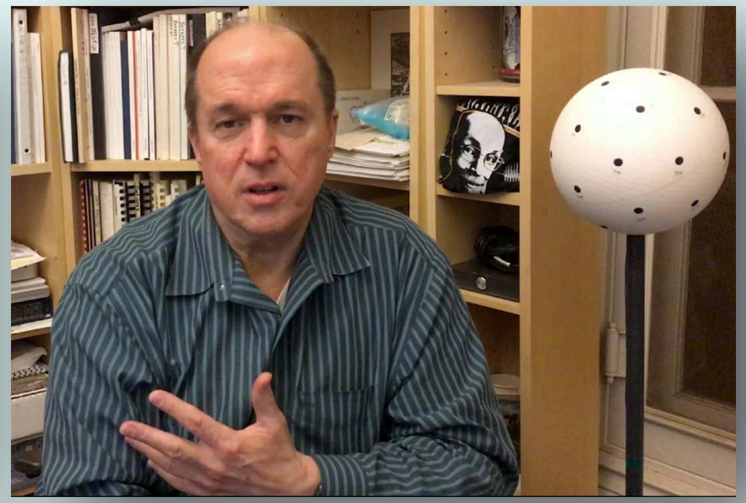
Karplus-Strong (KS) Algorithm (1983)



- Discovered (1978) as "self-modifying wavetable synthesis"
- Wavetable is preferably initialized with random numbers
- Licensed to Mattel
- The first musical use of the algorithm was in the work "*May All Your Children Be Acrobats*" written in 1981 by David A. Jaffe.

EKS Algorithm (Jaffe-Smith 1983)





$$H_p(z) = \frac{1-p}{1-p\,z^{-1}} = \text{pick-direction lowpass filter}$$

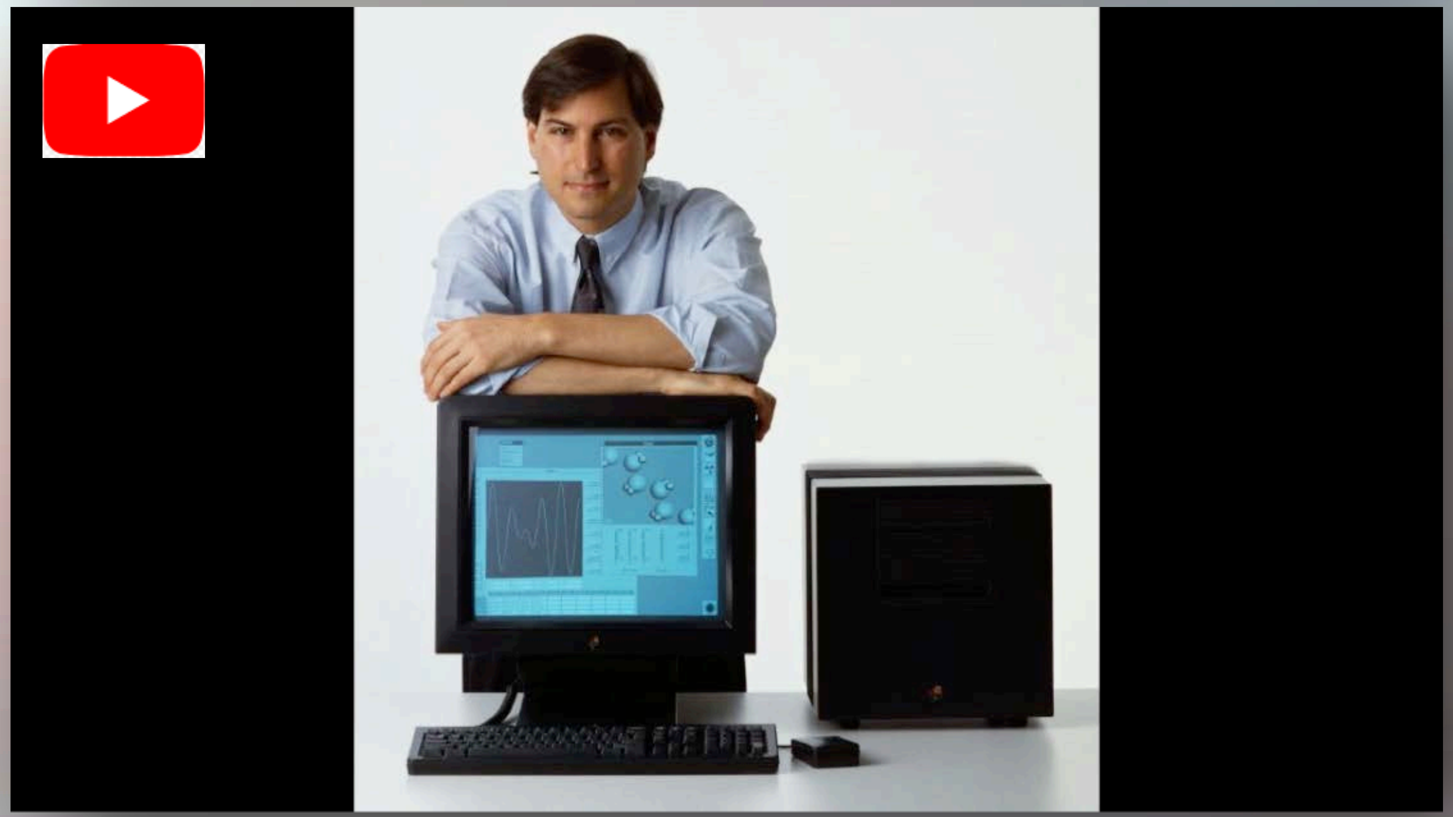
$$H_\beta(z) = 1 - z^{-\lfloor \beta N + 1/2 \rfloor} = \text{pick-position comb filter, } \beta \in (0,1)$$

$$H_d(z) = \text{string-damping filter (one/two poles/zeros typical)}$$

$$H_s(z) = \text{string-stiffness allpass filter (several poles and zeros)}$$

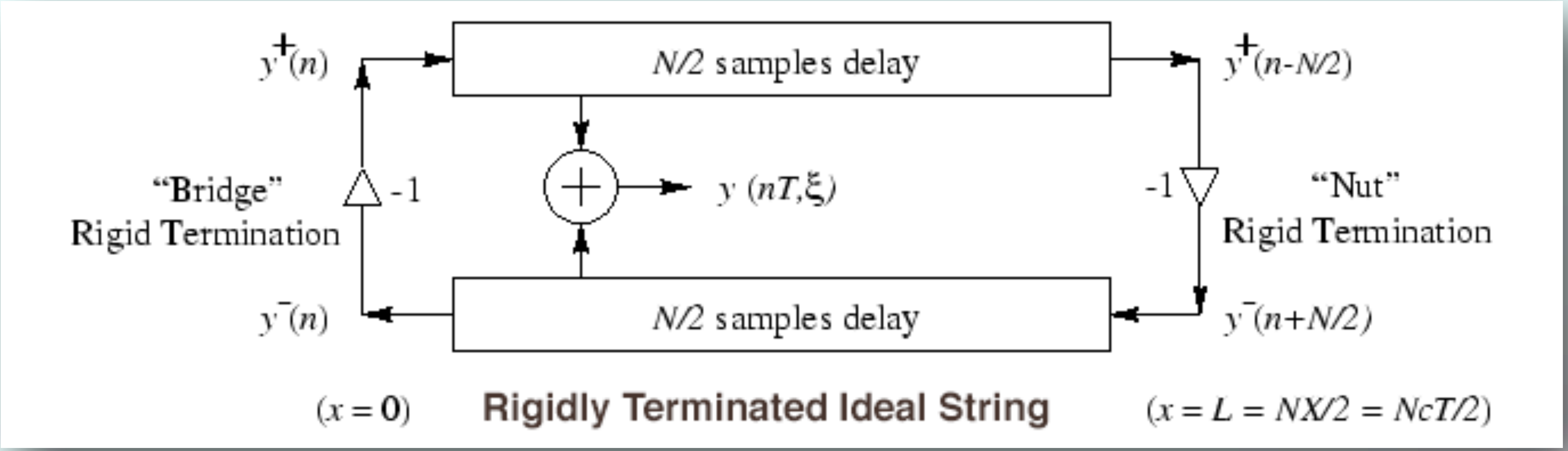
$$H_\eta(z) = -\frac{\eta(N) - z^{-1}}{1-\eta(N)\,z^{-1}} = \text{first-order string-tuning allpass filter}$$

$$H_L(z) = \frac{1-R_L}{1-R_L\,z^{-1}} = \text{dynamic-level lowpass filter}$$



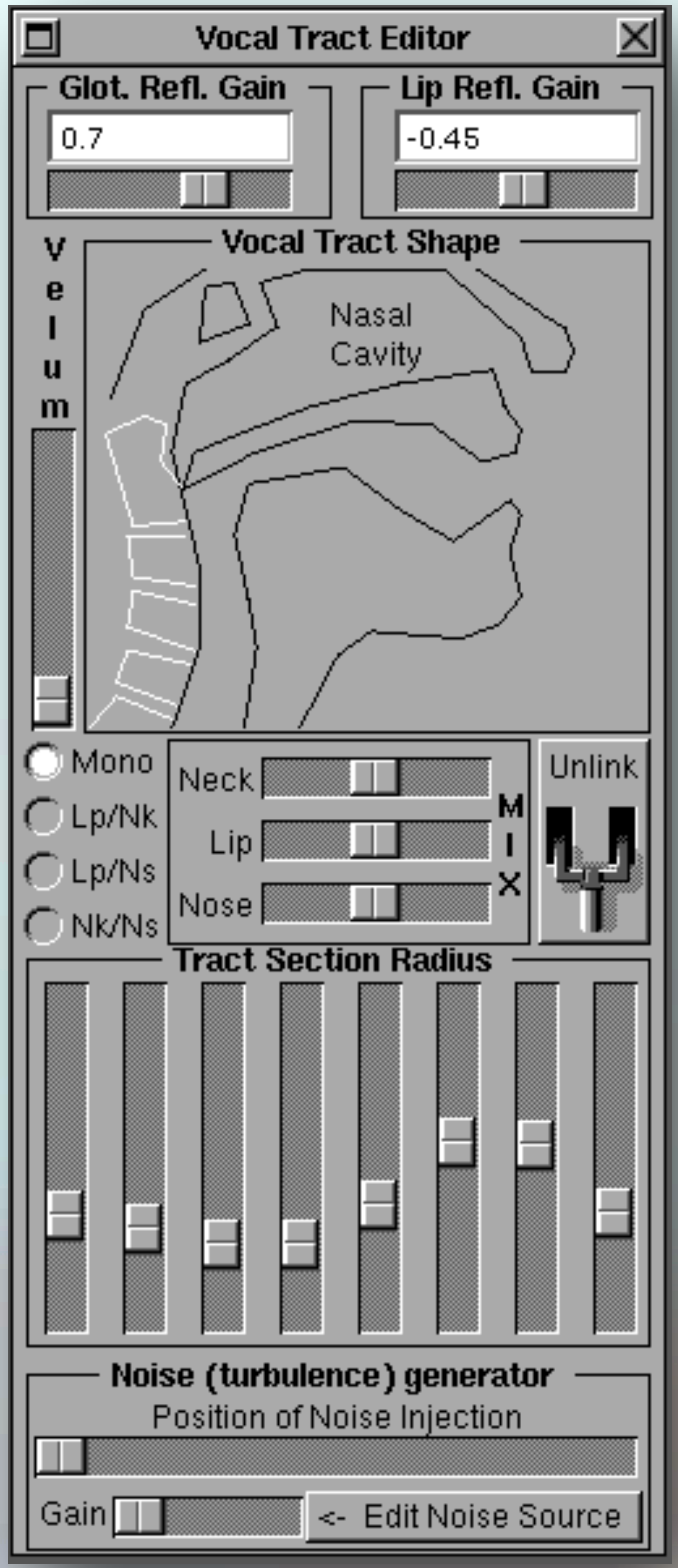
- Musical Example “Silicon Valley Breakdown” (Jaffe 1992)
- Musical Example BWV-1041 (used to intro the NeXT machine 1988)

Digital Waveguide Models (Smith 1985)



- Equivalent to d'Alembert's Solution to the Partial Differential Equation for a string (1747)
- Used for the Yamaha VL Family (1994)
- Shakuhachi, Tenor Sax

Sheila Vocal Track Modeling (Cook 1990)



Perry Cook's SPASM **"Singing Physical Articulatory Synthesis Model"**

Coupled Mode Synthesis (CMS) (Van Duyne) (1996)

- Modeling of percussion sounds
- Modal technique with coupling
- Tibetan Bell Model
- Wind Chime Model
- Tubular Bells Model
- Percussion Ensemble
- Taiko Ensemble

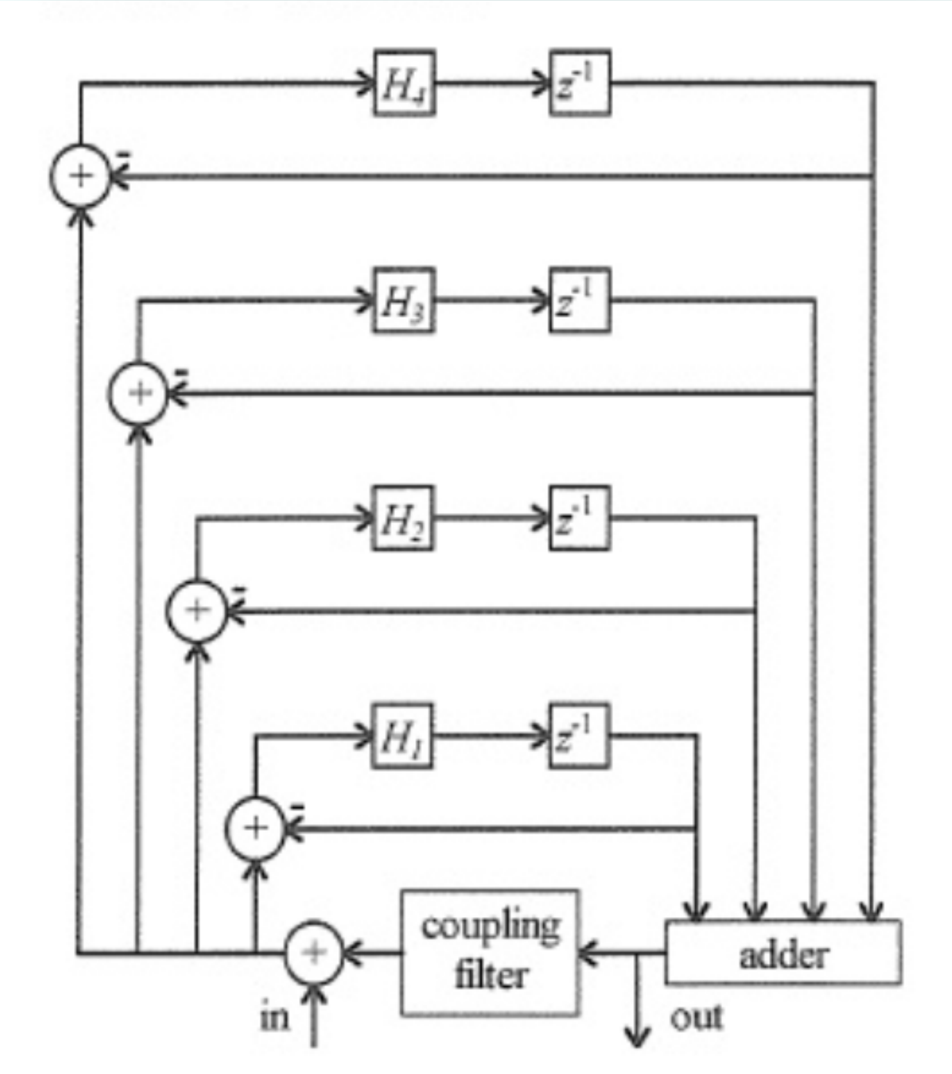
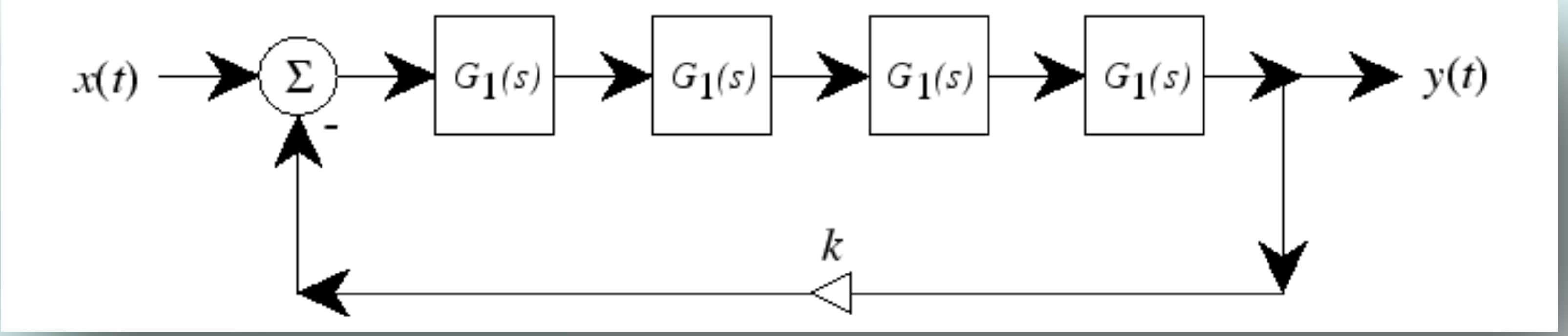
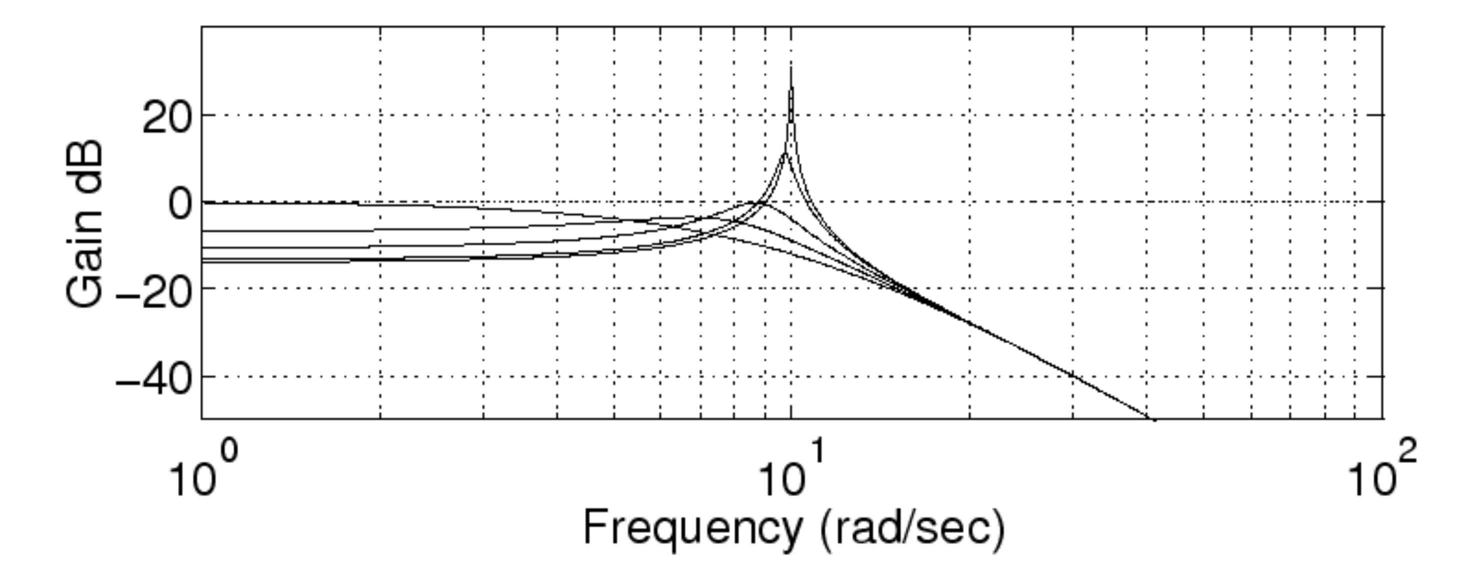


Figure 2: The Coupled Mode Filter Structure

Virtual Analog (Stilson-Smith) (1996)

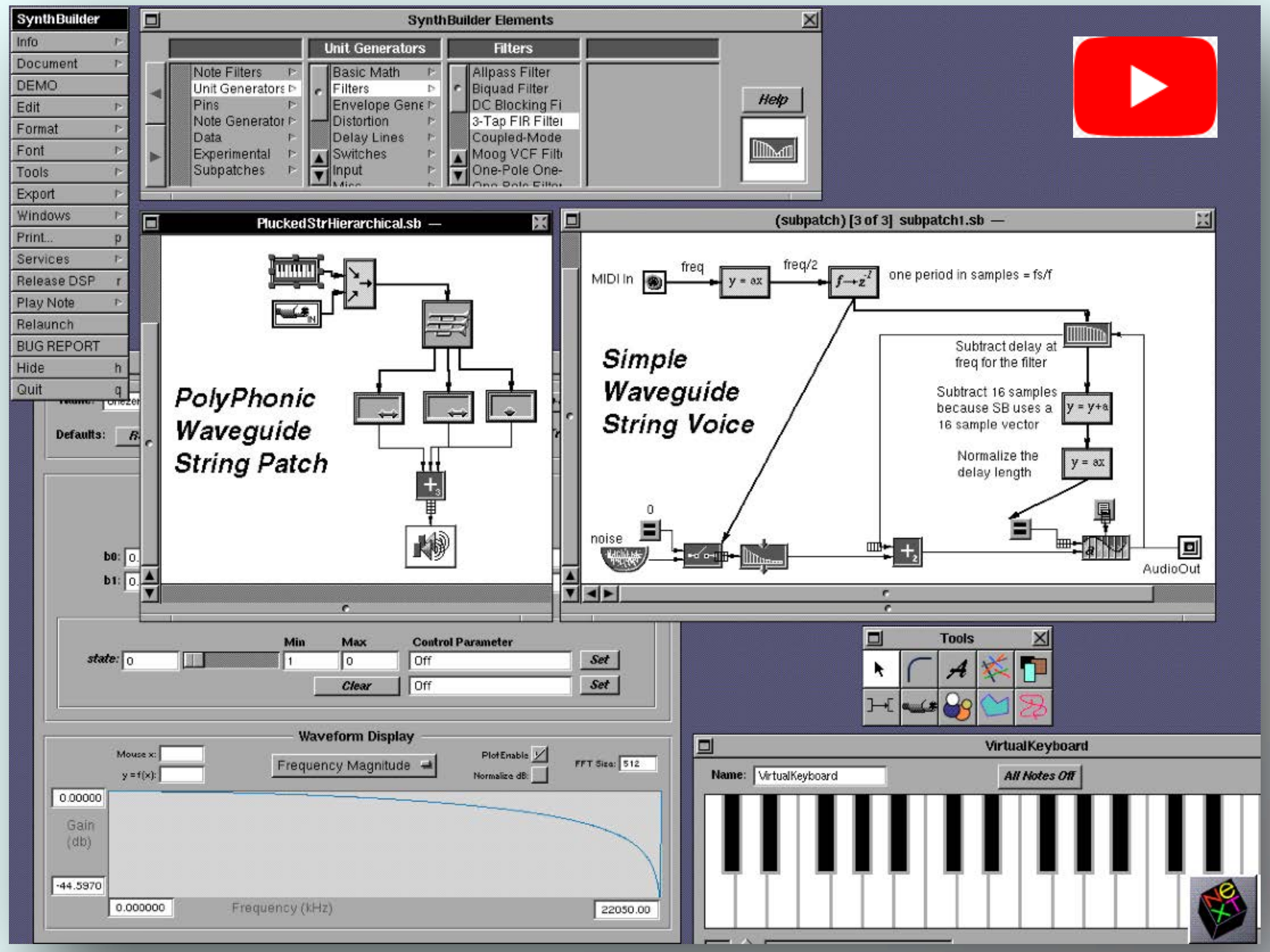
- Alias-Free Digital Synthesis of Classic Analog Waveforms
- Digital implementation of the Moog VCF. Four identical one-poles in series with a feedback loop.
- Sounds great!

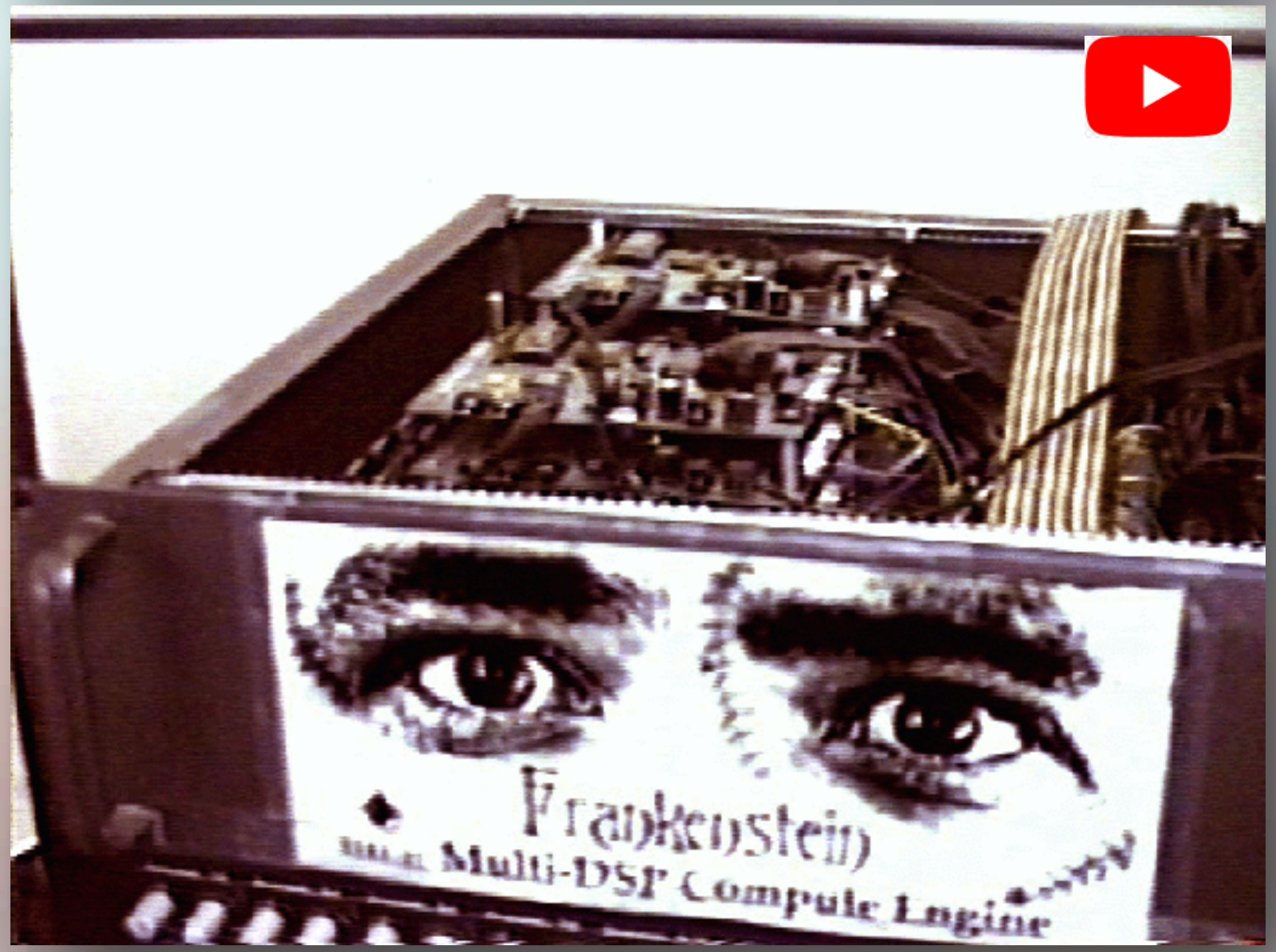




Full Ensembles all Physical Modeling (1997)

- Stanford OTL/CCRMA created the Sondius project to assist with commercializing physical modeling technologies.
- The result was a modeling tool known as SynthBuilder, and a set of models covering about two thirds of the General MIDI set.
- Many modeling techniques were used including EKS, Waveguide, Commuted Synthesis, Coupled Mode Synthesis, Virtual Analog.

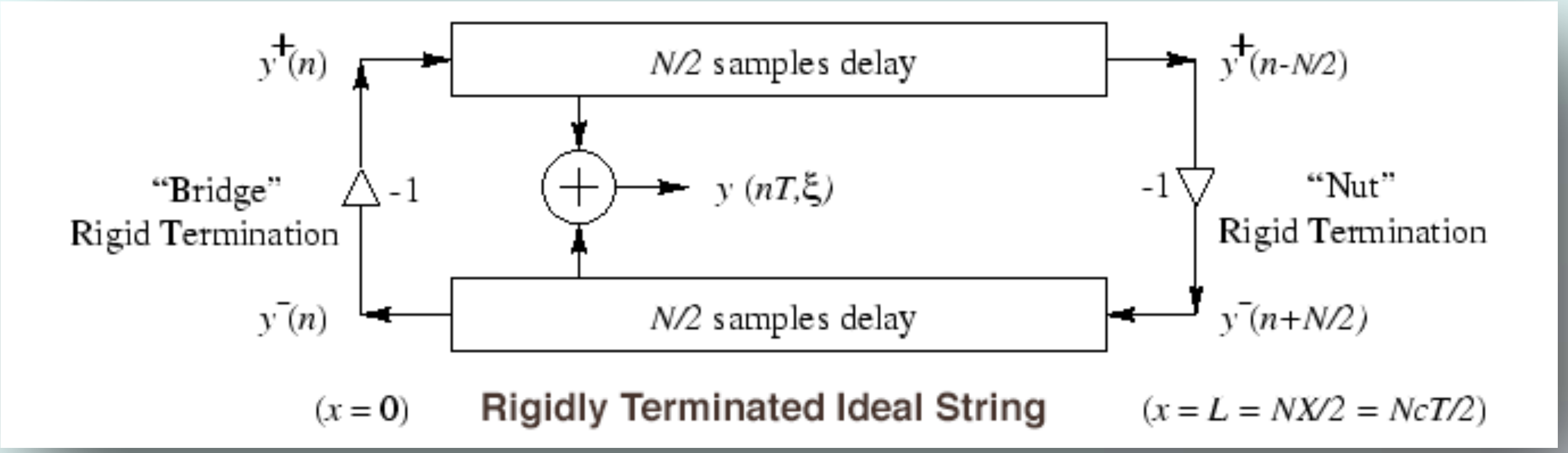


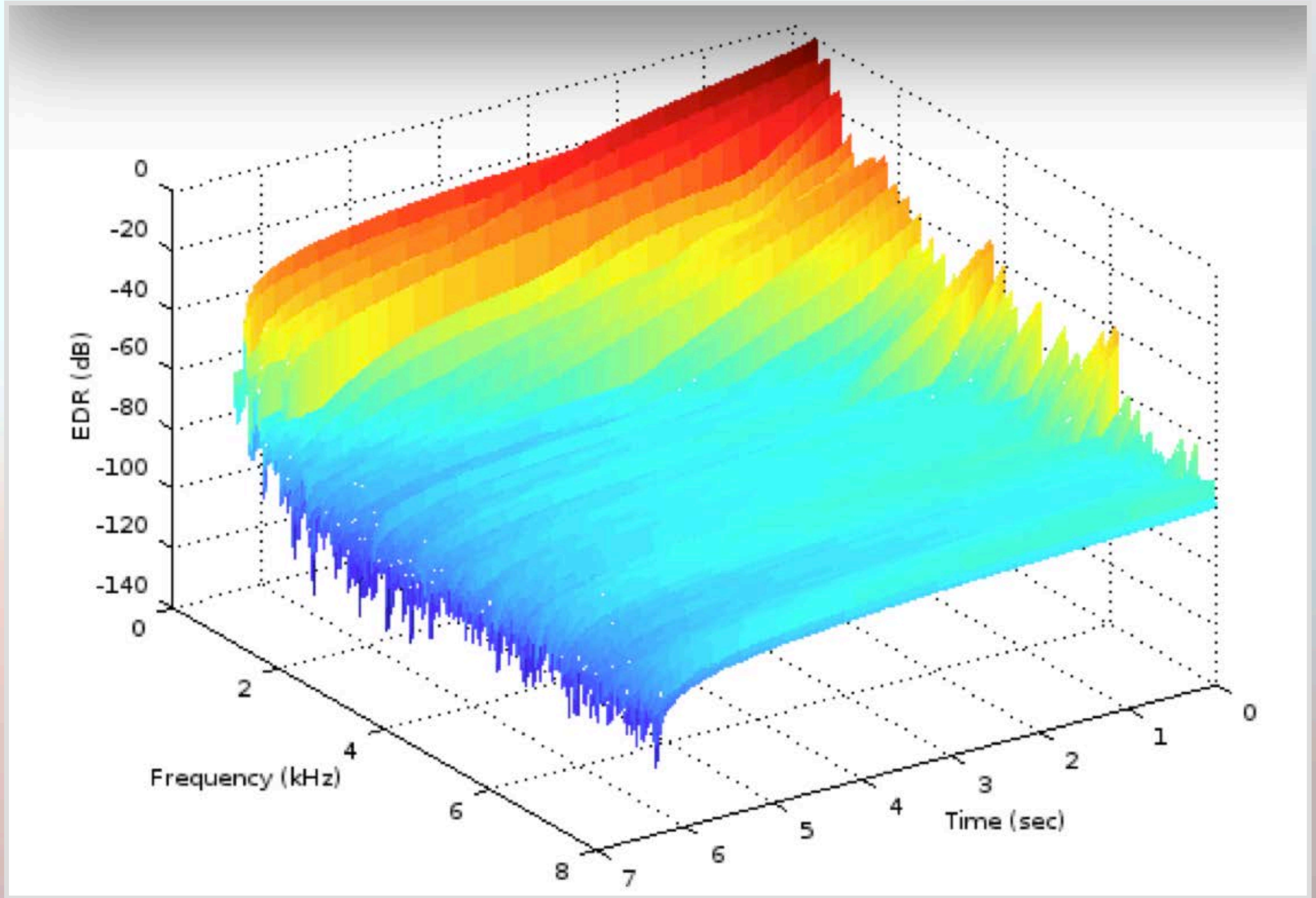


The Guitar Model

- A hybrid of Extended Karplus-Strong, Waveguide, Commuted Synthesis with extensions:
  - Harmonics and pinch harmonics
  - Pre-computed pickup excitations
  - Collisions for fret excitation
  - Sitar Bridge model
  - Body Model
  - Hexaphonic split
  - Doubling of courses
  - Statistical variations

- Calibrated from real recordings

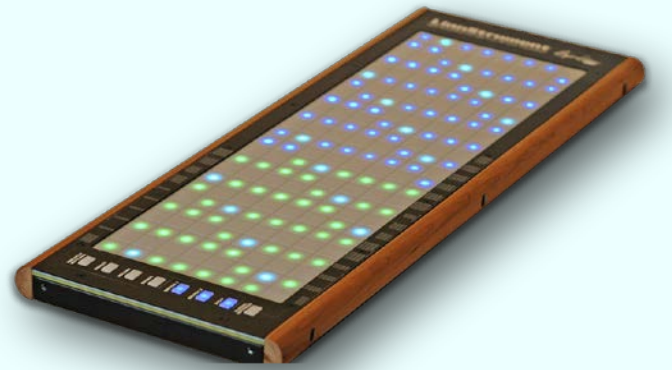




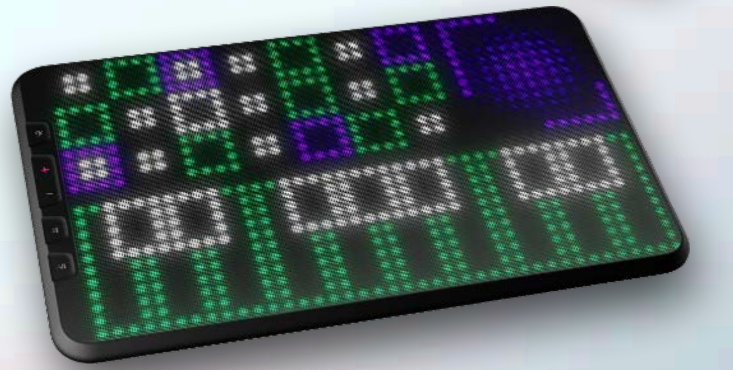
Current State of Physical Modeling, 2024

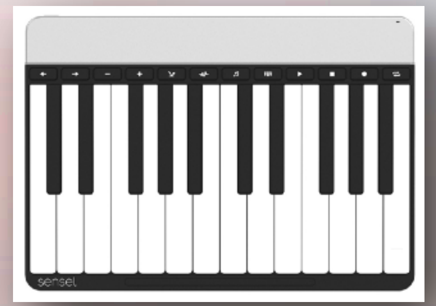
- Starting in 1994 Physical Modeling, became a niche due to the sudden drop in the cost of memory chips. Sampling has been the main technology for known instruments, with efforts to make samples more interactive.
- MPE has made Physical Modeling more viable.
- At this point there are many different controllers capable of the type of Multi-Dimensional control needed for Physical Modeling
- There are now many different Physical Modeling Products.

MPE MIDI and Modeling



- Haken Continuum
- Lumi Keys
- KMI K-Board Pro 4
- Ere Touch
- Sensel Morph
- Osmose
- Artiphon INSTRUMENT 1
- Joué
- GeoShred
- Seaboard
- LinnStrument





MPE
MIDI Polyphonic Expression

- A set of *conventions built on MIDI 1.0* to communicate per note, *multidimensional (x|y|z) control data*.

- Enables *independent expression* for each note or row.

- *Already supported* by over **250 hardware and software products**. MPE has legs

- MPE is a Lingua Franca for musical expression.

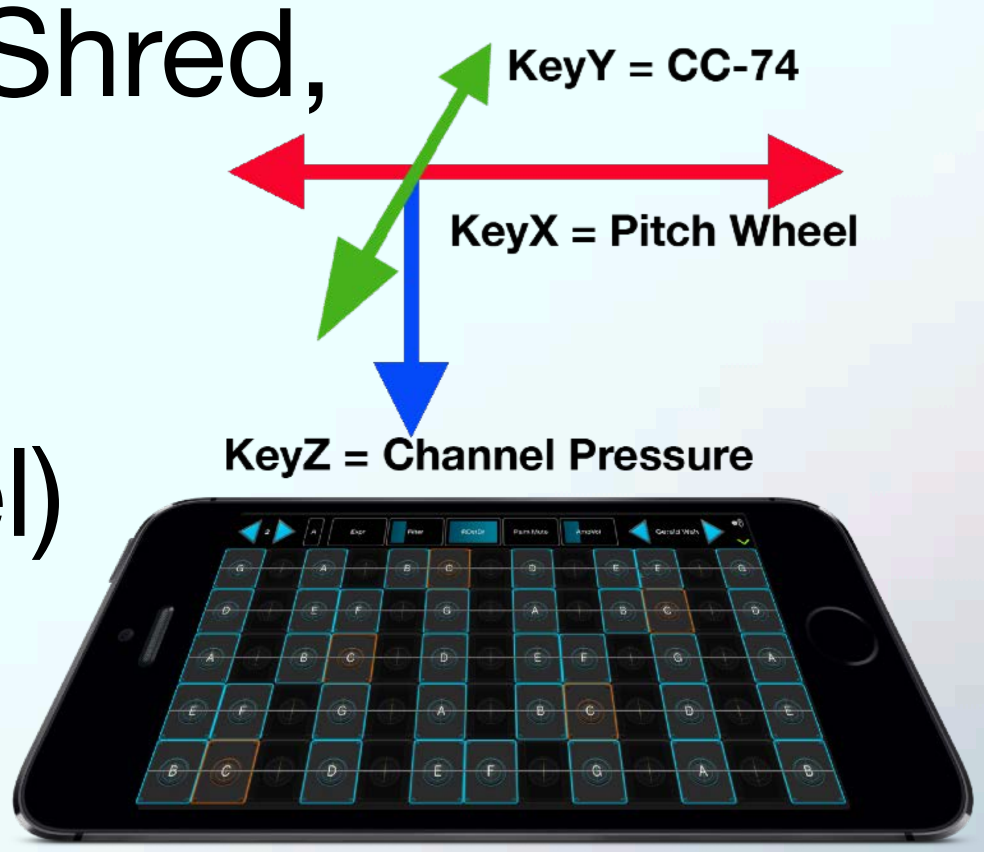
- The spec was ratified in January-2018, and a clarification revision was released April-2022: https://www.midi.org/specifications/midi1-specifications/mpe-midi-polyphonic-expression

- MIDI 2 profile is in the works and expected to be published by NAMM/2024

MPE in a Nutshell

- Derivative of MIDI Modes 3/4; enabled with RPN-6/0

- Can be Channel-Per-Note (for Keyboards, like the Seaboard) or Channel-Per-Row (String) (GeoShred, LinnStrument, Guitar Controller).



- Expression Control Conventions (per Channel)
    - o KeyX – Pitch Bend (Roli calls this *Glide*)
    - o KeyY – CC-74 (Roli calls this *Slide*)
    - o KeyZ – Channel Pressure (Roli calls this *Press*)

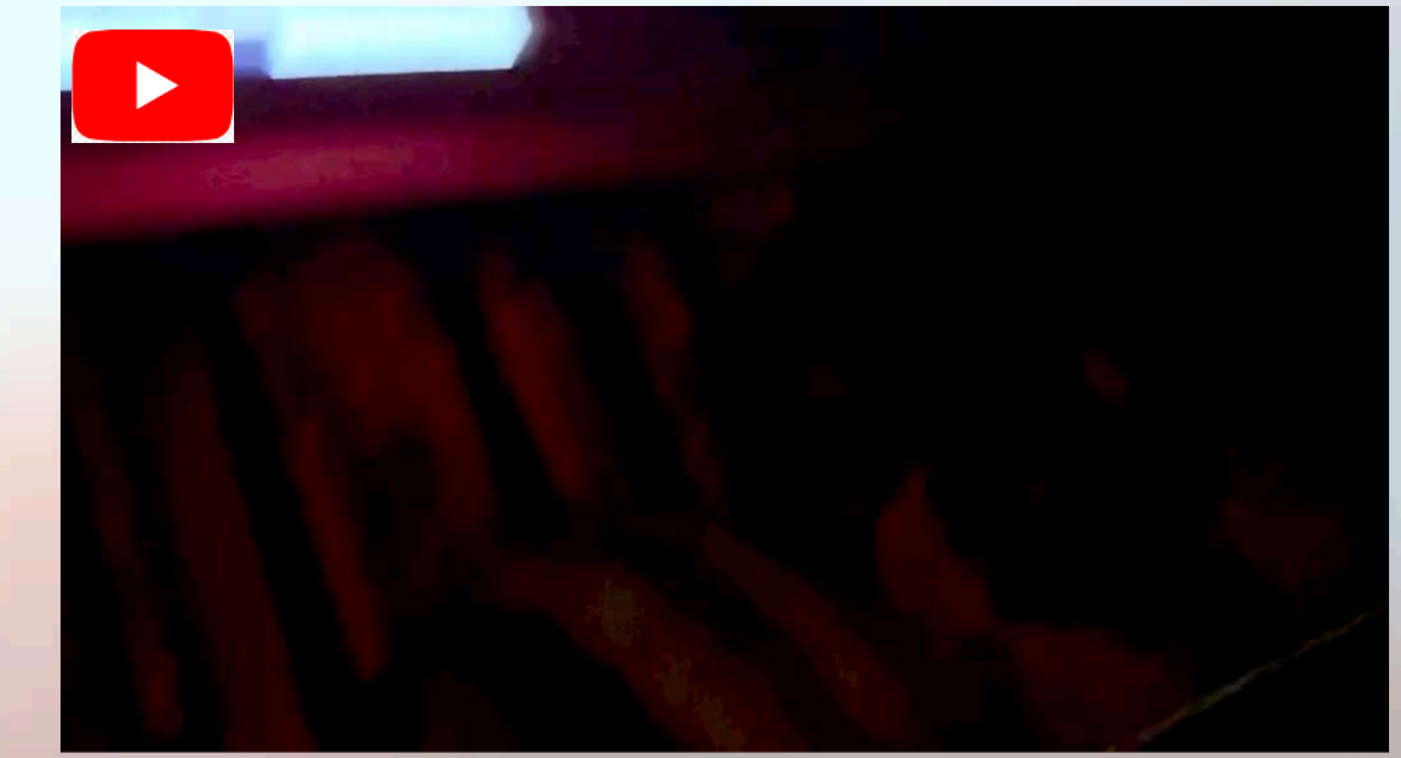
- Provides for Manager Channel (typically 1 or 16) that globally controls the MPE Member Channels (ie modWheel to all Member Channels)

The Importance of Pitch Fluidity

- Pitch Fluidity is an essential expressive metaphor for musical performances around the world. For example South Asian Music.

- MPE directly addresses Pitch Fluidity by supporting per-note multi octave pitch bending.

- Though not a part of MPE, Pitch Rounding is essential to enable performers to play in-tune in any given temperament. Roli, Linnstrument, GeoShred, et al support pitch rounding.



Modeling Synthesis and MPE

- Models are parameterized and as such can be musically expressive.
- Until recently, the options for expressing musical parameters were limited, *and affected all notes,* pitch wheel, mod wheel, knobs…
- **MPE creates a standard for individual expressive control on a per-note or per-row (string) basis.**

MPE + Modeled Synthesis
… BIG DEAL

- MPE makes a whole new generation of controllers possible. **Whatever instrument makers dream up!**
- MPE offers an expressive performance mechanism for parameterized synthesis methods. Physical Modeling, Virtual Analog, FM, … others
- **Together, whole is greater than the sum of the parts!**

Special Modeling Considerations for South Asian and Chinese Instruments

- Sitar, Veenas, Sarod, Sarangi (bowed) - Strings, Strumming, Sympathetic Strings, Parabolic Bridge, Strumming
- Bansuri, Shehnai, Nadaswarm, Dizi, Suona - Blown Instrument, Overblow
- Pippa - Tremolo lunzhi (輪指) Technique, Strumming
- Erhu, Zhonghu, Gaohu - Bowed

Questions?

You can reach me at
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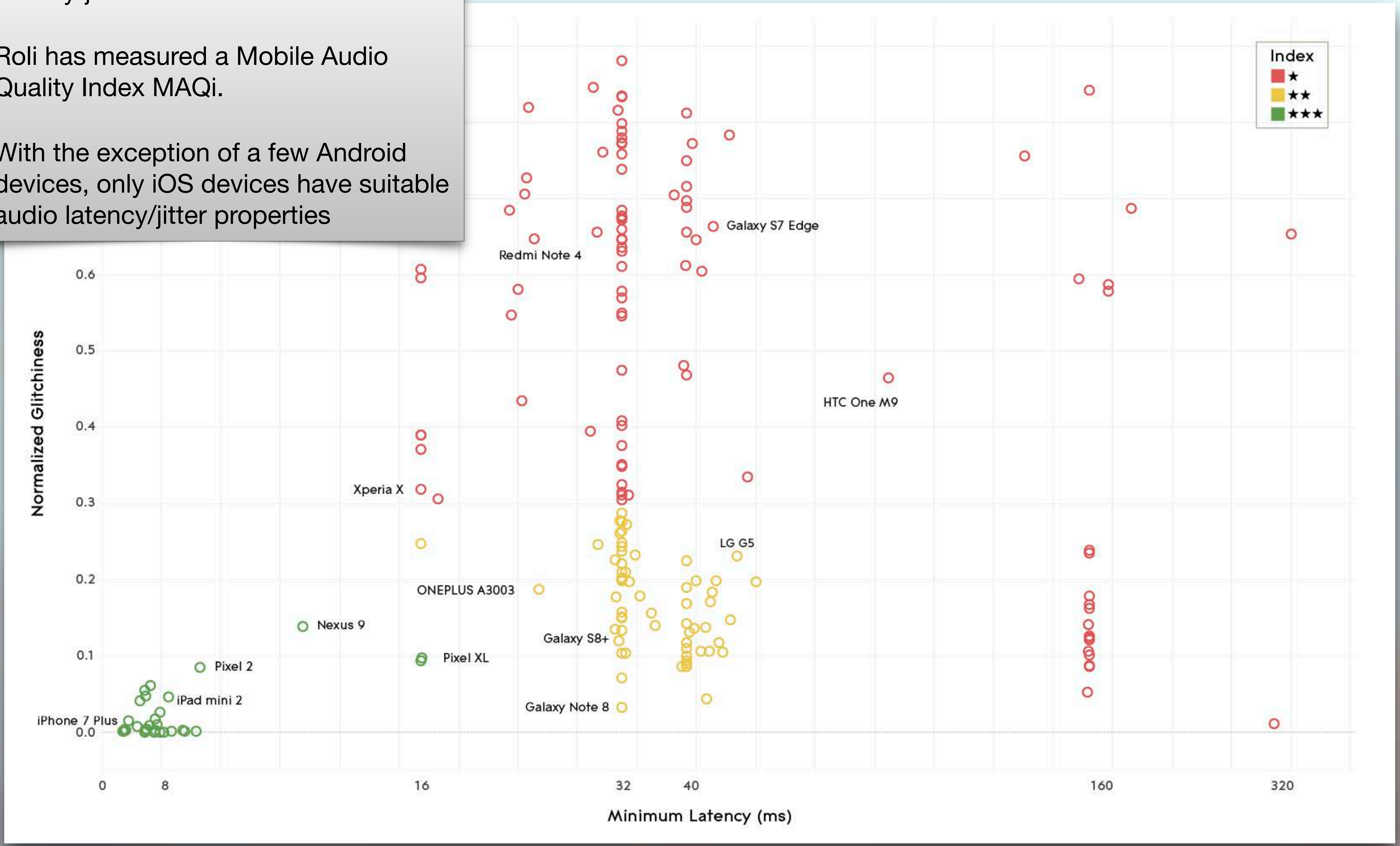
Why Android is a Challenging Platform for Audio Products Targeted for Musicians

- Most Android devices have **audio** latency/jitter issues.
- Roli has measured a Mobile Audio Quality Index MAQi.
- With the exception of a few Android devices, only iOS devices have suitable audio latency/jitter properties



What about Latency?

- The largest source of latency (for ios) appears to between screen interaction and the guitar model. Note that the audio buffer latency is about 5ms.
- We started at 180ms screen to audio out.
- We brought this down to 25-35ms by replacing Apple's gesture handlers with a custom gesture handler. This makes sense. Gesture handling requires analysis of a moderate amount of state to initiate an action.
- MIDI to Audio Latency is about 20-30ms.
- PowerStomp which is audio-in/effects chain/audio out is around 18ms.
- Latency to the internal speakers on iOS devices seems to have gotten a bit poorer over time. Probably due to DSP processing for the head phone jack.

Thanks!

- Mary Albertson
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- Yann Orlarey
- Stephane Letz
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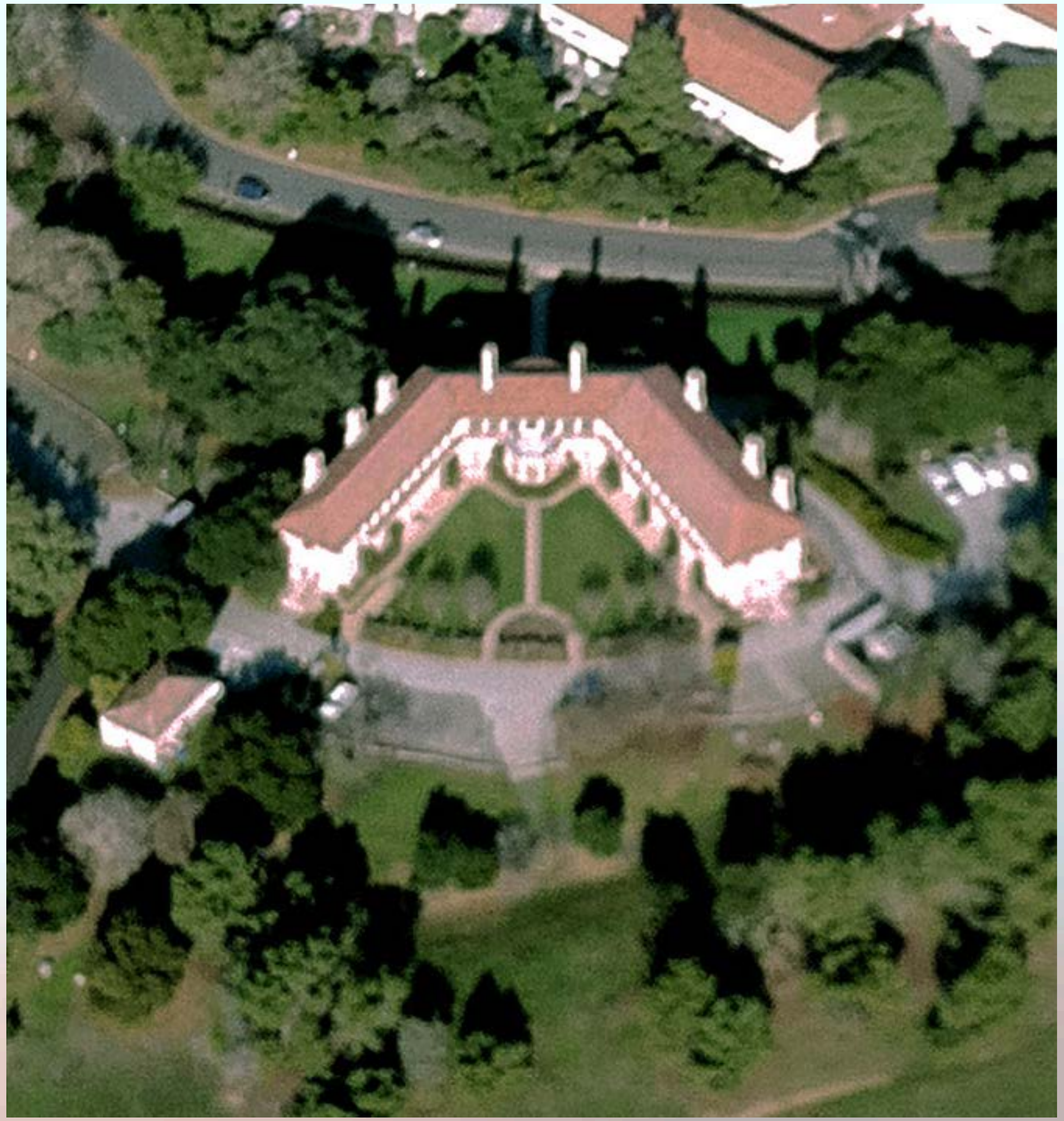
- Danny Petkevich
- Nick Porcaro
- Bill Putnam
- Jordan Rudess
- Danielle Rudess
- Kent Sandvik
- Julius Smith
- Tim Stilson
- David Van Brink
- Scott Van Duyne
- Yamaha



And CCRMA