

GeoShred, A Musical Instrument App based on Physical Modeling Synthesis



Pat Scandalis

(CTO, moForte)

Jordan Rudess

(President, Wisdom Music)

Dr. Julius O. Smith III

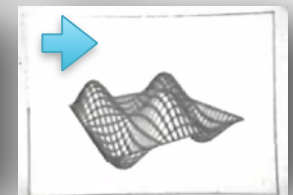
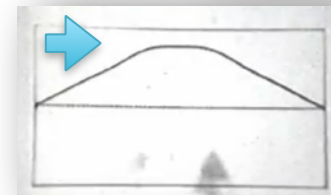
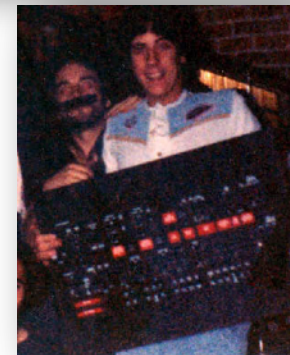
(Founding Consultant, moForte)

Nick Porcaro

(Chief Scientist, moForte)

About Pat...

- 36 years in the Silicon Valley as an Engineer
- Built my first monophonic electronic instrument in 1970 from a Radio Shack kit.
- Gigged with an Arp Avatar guitar synth (1978)
- Computer Modeling of strings and membranes (1981)
- Researcher in Physical Modeling at Stanford/CCRMA (1994)
- CEO/CTO of moForte



This Deck and our Full Deck on Physical Modeling Technology:

<http://www.moforte.com> go to the “News and Media” section

Or

This Deck

www.moforte.com/moforte-bish-bash-presentation-22819/

The Full Physical Modeling Deck:

<http://www.moforte.com/berklee-voltage-physical-modeling/>

GeoShred



- GeoShred is an award winning expressive musical instrument, which models the physics of a strings
- GeoShred is a collaboration between Rock Star, Jordan Rudess and moForte inc which includes Stanford/CCRMA professor Dr. Julius O. SmithIII
- Winner of the 2017 Electronic Musician Editor's Choice Award as "*one of the most innovative, groundbreaking products to emerge in the past twelve months*", GeoShred is used by tens of thousands of musicians in in 44 countries with millions of video views.
- Currently a finalist for the prestigious Guthman New Musical Instrument Competition
- GeoShred's has a performance surface with “almost magic” pitch rounding algorithms is coupled with a model of the physics of strings, support for AUV3, MIDI In/Out, MPE, 3D Touch and microtonality

Virtuoso Artists in 44 Countries have Embraced GeoShred

Props

"GeoShred is brilliant- it's a real instrument."
 – **Eddie Jobson - Roxy Music, Jethro Tull,
 Frank Zappa, UK**

*"A fantastic new invention which is going to
 revolutionize the way music is played,
 expressed and learned! 'GeoShred' is one of
 the foremost best musical inventions I've had
 the pleasure to experience in recent years.*

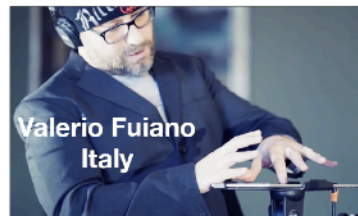
*Definitely 5 stars out of 5!
 GIGANTASTIVISSIMO....R...A...Z !!!!!"*
 – **Patrick Moraz, Yes, Moody Blues**

*"That's just nuts. You're [Jordan] the best-
 guitarist-without-a-guitar of all time."*
 – **Joe Satriani**

*"GeoShred is a breakthrough [musical
 instrument] for the iPad. Some might think it's
 the best evidence yet that there has indeed
 been reverse engineering of alien technology,
 but if that's the case, then aliens play guitar...
 and worship Jimi Hendrix."*

– **Craig Anderton, Harmony Central,
 Founding Editor Electronic Musician
 Magazine**

*"...one of the most innovative,
 groundbreaking products to emerge in the
 past twelve months"*
 - **Electronic Musician, 2017 Editor's Choice**



**Valerio Fuiano
 Italy**



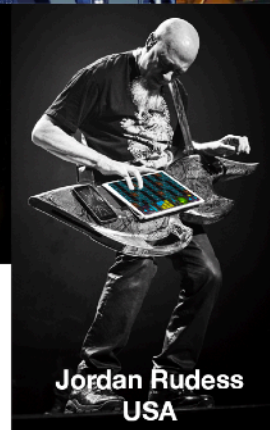
**Diego Tejeida
 Mexico**



**Greg Hosharian
 USA**



**Navneeth
 Sundar
 India**



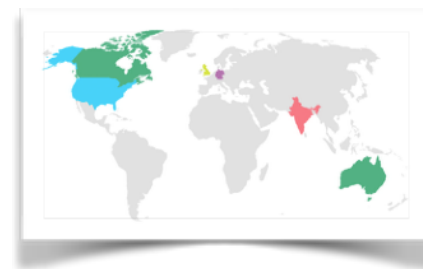
**Jordan Rudess
 USA**



**Mahesh Raghvan
 Dubai**



**Gerald Peter
 Austria**



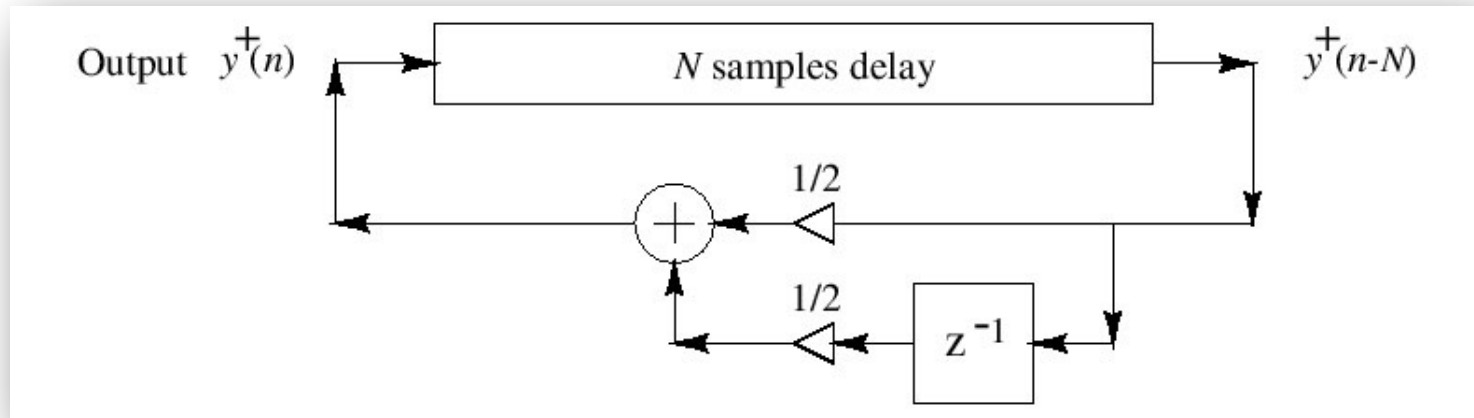
**27% of GeoShred Users
 are in India**

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.**

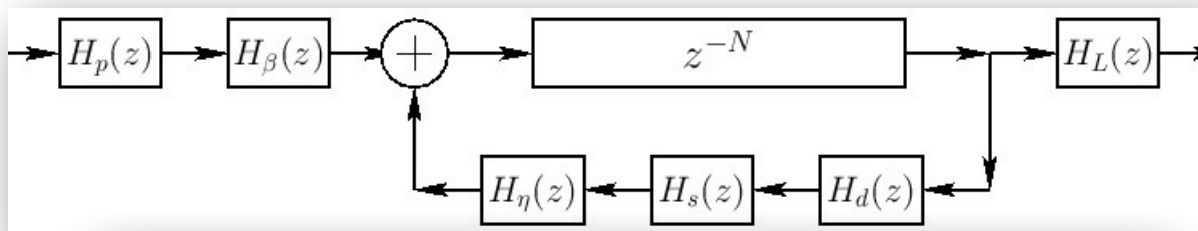
$$\frac{\partial^2 y}{\partial t^2} = \frac{1}{v_w^2} \frac{\partial^2 y}{dt^2}$$

Karplus-Strong (KS) Algorithm (1983)



- Discovered (1978) as “self-modifying wavetable synthesis”
- Wavetable is preferably initialized with random numbers
- Licensed to Mattel

EKS Algorithm (Jaffe-Smith 1983)



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

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

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

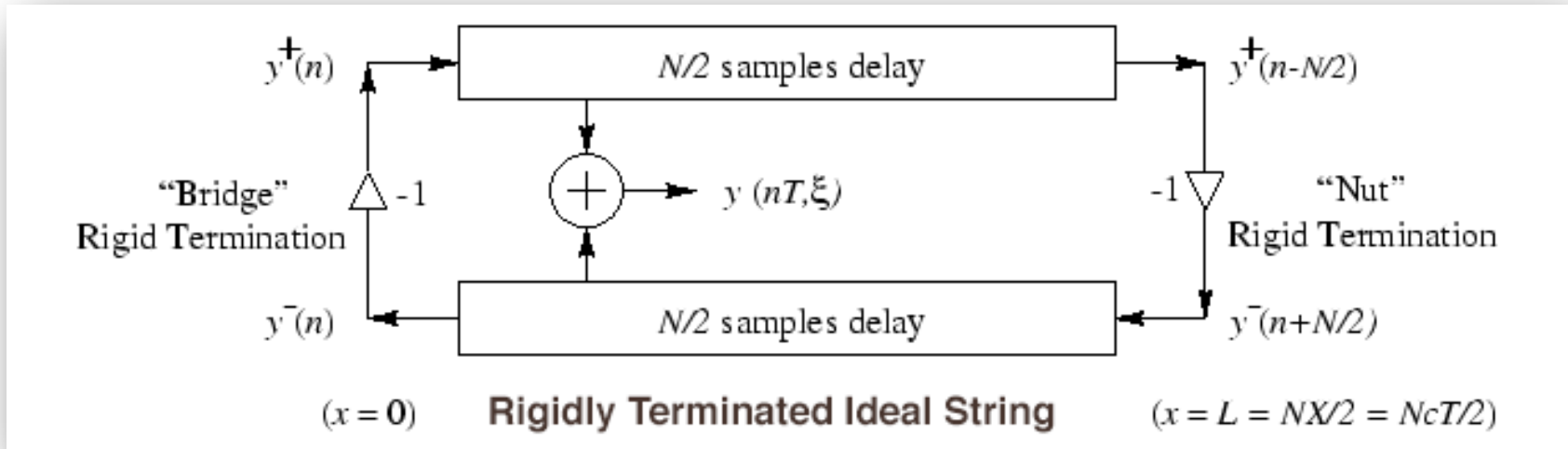
$$H_s(z) = \text{string-stiffness allpass filter (several poles and zeros)}$$

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

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

- The first musical use of the algorithm was in the work “*May All Your Children Be Acrobats*” written in 1981 by David A. Jaffe. [\(MP3\)](#)
- Musical Example “Silicon Valley Breakdown” (Jaffe 1992) [\(MP3\)](#)
- Musical Example BWV-1041 (used to intro the NeXT machine 1988) [YouTube](#)

Digital Waveguide Models (Smith 1985)



- Equivalent to the Kelly-Lockbaum vocal tract model with all but two scattering junctions removed, and the remaining two made into pure reflections or filters.
- Useful for efficient models of
 - Strings
 - Bores
 - plane waves
 - conical waves

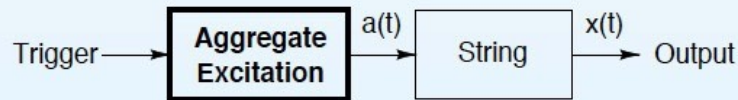
Commutated Synthesis (Smith) (1994)



Schematic diagram of a stringed musical instrument.

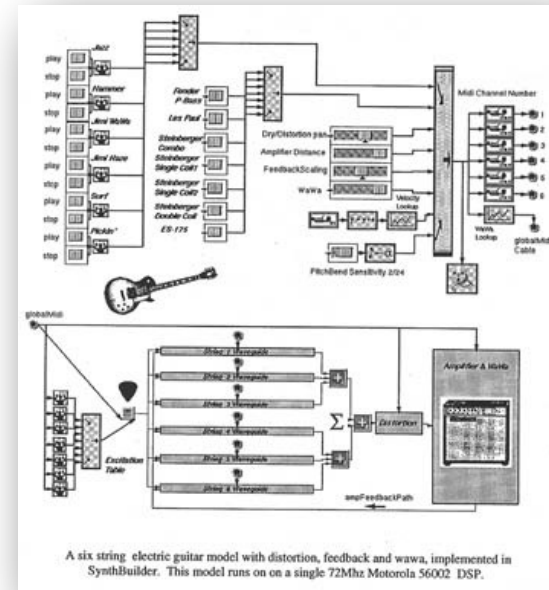
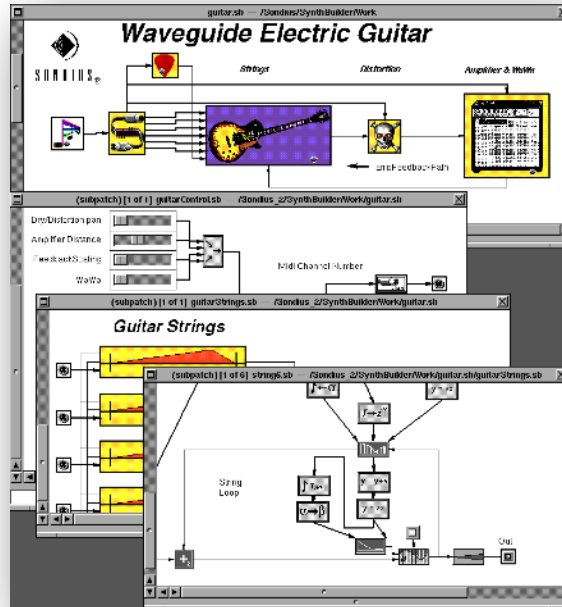


Equivalent diagram in the linear, time-invariant case.



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

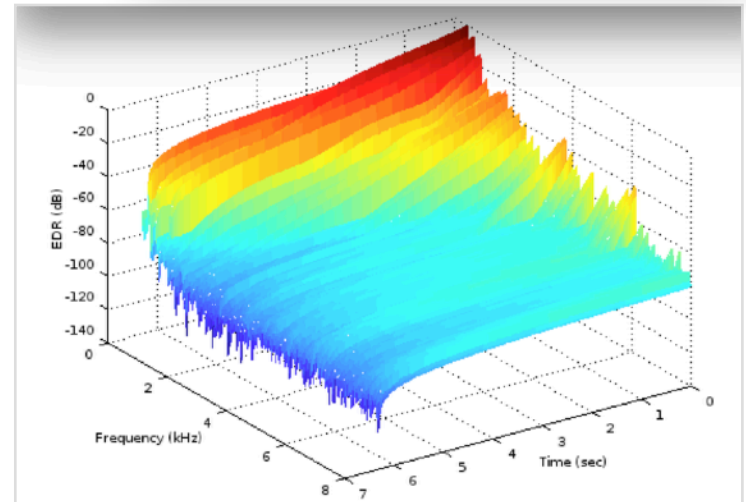
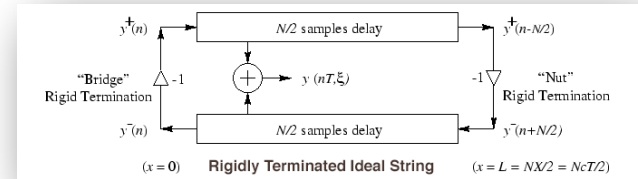
The Sondius Electric Guitar (1996)



- Pick model for different guitars/pickups (commuted synthesis, Scandalis)
- Feedback and distortion with amp distance (Sullivan)
- Wah-wah based on cry baby measurements (Putnam, Stilson)
- Reverb and flanger (Dattorro)
- Hybrid allpass delay line for pitchBend (Van Duyne, Jaffe, Scandalis)
- Performed using a 6-channel MIDI guitar controller.
- With no effects, 6 strings ran at 22k on a 72 Mhz Motorola 56002 DSP.
- Waveguide Guitar Distortion, Amplifier Feedback ([MP3](#))

The moForte Algorithm

- A hybrid of EKS, 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
- Implemented in Faust, an Audio DSP language.



Questions?

One More Thing..

Stanford/CCRMA Open House Tomorrow 3/1/19

Talk about running Faust Algorithms on the SHARC Audio Module

