Adventures and Evolution
in
Visual Music Instruments

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Who am I?

- Cross-functional maker / artist
    - software, hardware, music, visual
- Training
    - Software engineer (45 years), casual / lifelong musician
- Interests
    - Algorithmic composition, programming languages, user interfaces (soft and hard), networking
- Motivations
    - Fun, learning, experimentation, socialization

What do I do?

- Software
  - Tools for generating and manipulating music and visuals
- Hardware
  - Custom controllers
  - Installations for events like Burning Man
- Instruments
  - Evolution from music to visuals to visual music
  - Evolution from casual to performing

Types of Instruments

- Casual Instruments
  - Simple and discoverable with few or no instructions
  - Immediate gratification, fun, and pleasing results
  - Direct control over output is obvious to the player
  - Each person sounds different and can be uniquely creative
  - Path to proficiency is nice to have, but not required
- Performance Instruments
  - Prioritize proficiency and control
  - Instructions or training usually required
  - Proficiency requires practice, learning curve
 - Visualizations (real or virtual) for audience are beneficial

A History of Instruments and Installations

- 21st Century Caffeine-based Life Form
- Oops, I made a typo
- Dance Pads
- Dancing under the Stars of Lyra
- Radio Free Quasar
- Finger Painting with Planets
- Finger Fresco
- Galaxy
- LoopyCam
- UniLooper
- Space Palette and Space Palette Pro

Where it all started - KeyKit

- A programming language specialized for algorithmic and realtime manipulation of MIDI, started in 1985

- Entire graphical user interface and all tools written in the language and provided as source code in library

- Incremental development for 10 years enabled development and exploration of a wide variety of tools

- Tools began to turn into instruments

"21st Century Caffeine-based Life Form" at Woodstockhausen 2000
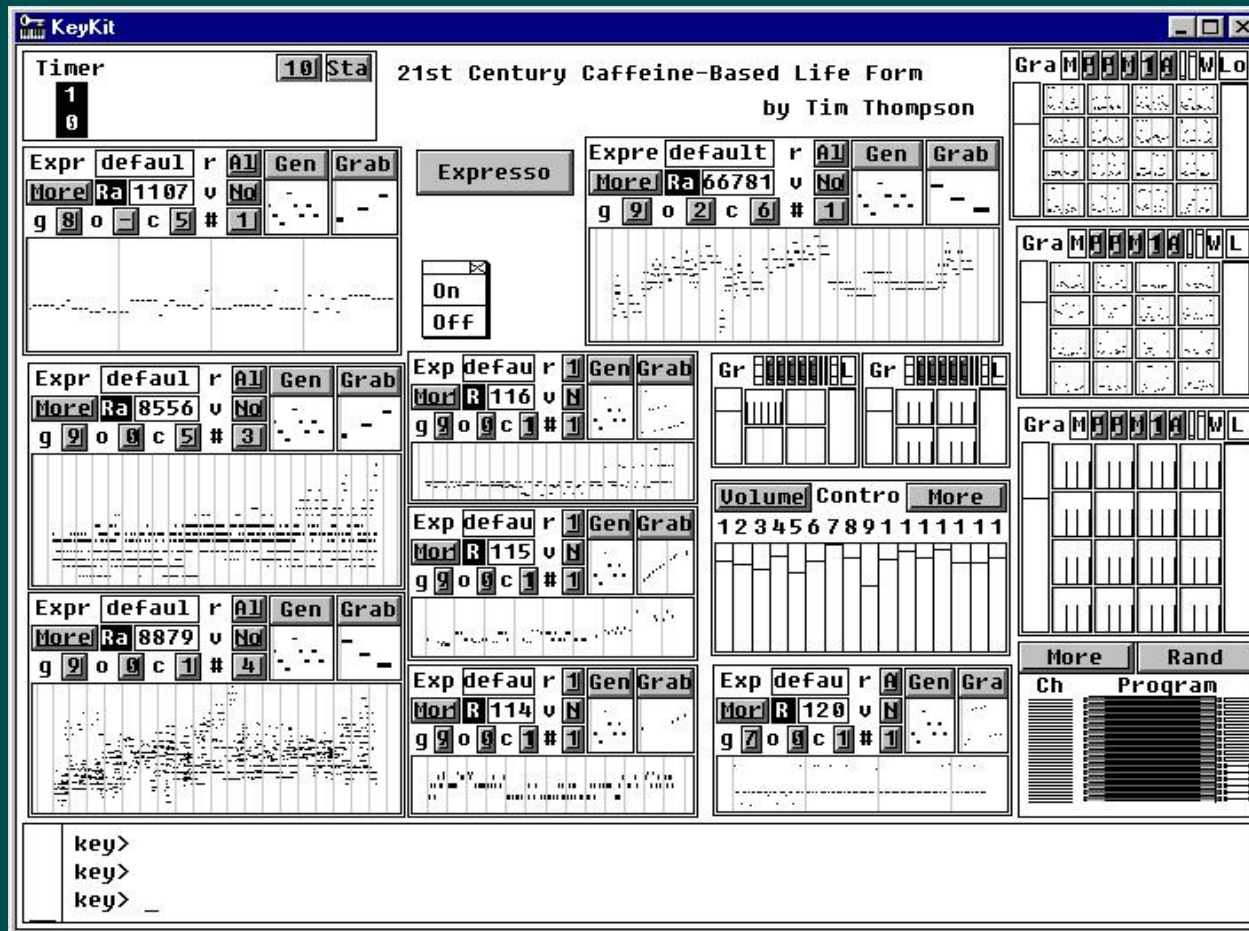
● 7 L-systems fractal tools manipulated live

Oops, I made a typo

- Woodstockhausen 2001

- All-QWERTY Performance

Dance Pad Performances

- With Wireless QWERTY keyboard

- Woodstockhausen performance – Happy Feet   Movie
  - Done entirely on 4 dance pads
  - No hands, No light, and EL-wire-outlined pants

Dancing under the Stars of Lyra

Burning Man 2003

Dancing under the Stars of Lyra

Movie1

Movie2

Radio Free Quasar

Audio

- Burning Man 2004
- Python-based VST audio manipulation
- Audio-reactive visuals generated with a laser pointed at a speaker-mounted mirror.

Graphics gets interesting in 2005

- Affordable equipment
  - Webcams
  - Video mixers
  - Security cameras
  - Video processors
- GPUs and CPUs fast enough for realtime use

Dud - Visual Music experiments

- **dud** - an improvised art ensemble of musicians
- Collaborative environment for experimenting with visuals
- Python used for OpenGL graphics
- KeyKit interface to input devices (MIDI, iGesture)
- MIDI sliders and buttons control graphics parameters
- MIDI from drummer triggers graphics
- Text typed interactively is used as graphics
- Words typed interactively can immediately search clip-art database whose images are then used as graphics

Dud - examples

- John Patrick's : drum-triggered graphics, camera
  - movie

- 21 Grand : dancers, indoor/outdoor cameras, four projectors, FreeFrame video looping
  - movie

- Chico : multitouch drawing, Python OpenGL graphics, webcam
  - movie

A Custom Controller for Performing Graphics

- Fingerworks iGesture pads
  - Capacitive multitouch with finger area detection
  - Extremely responsive, excellent driver support
  - **First exposure to 3D input**

Different Skies 2007

- 20 Electronic musicians and one visual performer gathered for a week-long workshop at Arcosanti in Arizona

- Music was composed for a concert at the end of the week

- Interactive graphics (no clips) was composed to match each piece of music

- The performance rig

- A two-hour concert

full concert

2 hours in 2 minutes

Different Skies 2007

Finger Fresco

- Maker Faire 2007
- Instrument for manipulating:
  - Music, Graphics, and Live Camera

Movie

Finger Painting with Planets

- Maker Faire 2008

Movie

Finger Painting with Planets

- Installation for people to play with

- Generates music and graphics simultaneously

- Controller with buttons, knobs, LCD, multitouch pad

- Fingers on pad trigger music or graphics

- Graphics motion is simulated gravitational attraction

- Collisions of planets trigger music

- Musical keyboard controls (only) selection of note
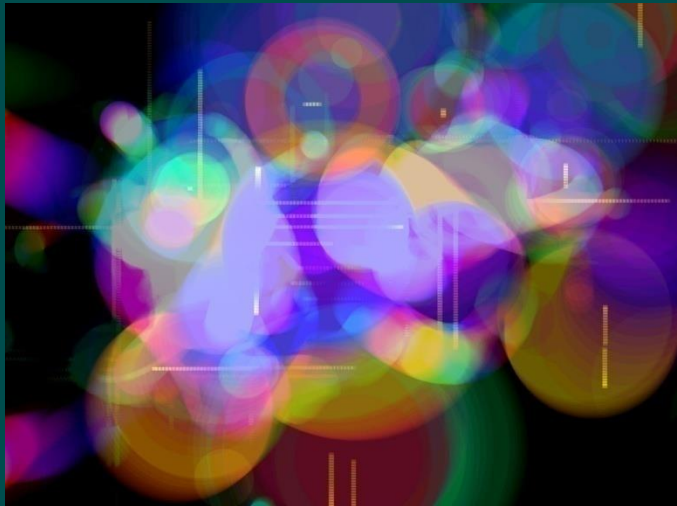
Finger Painting with Planets
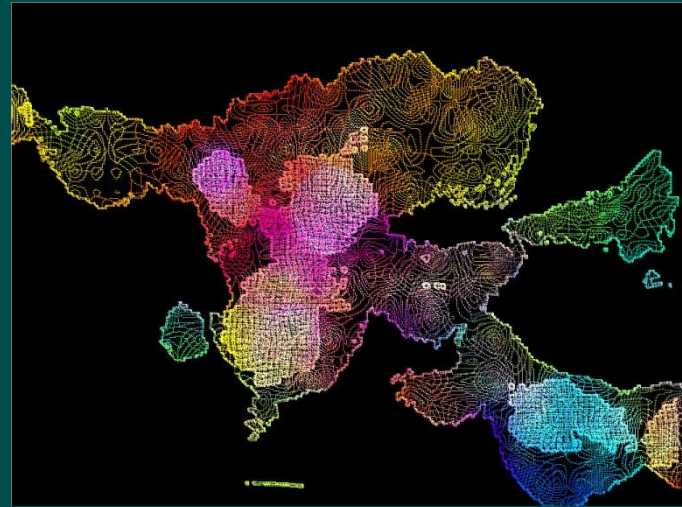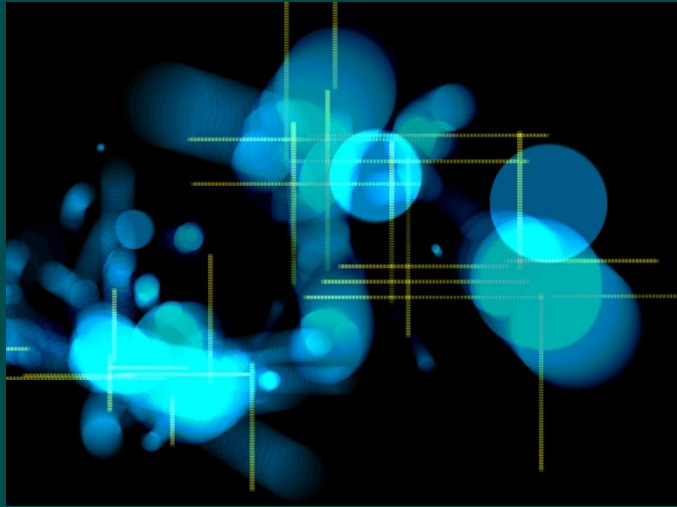
- Night Lights show at Climate Theater

  Movie

- Yuri's Night

  Movie

Finger Painting with Planets
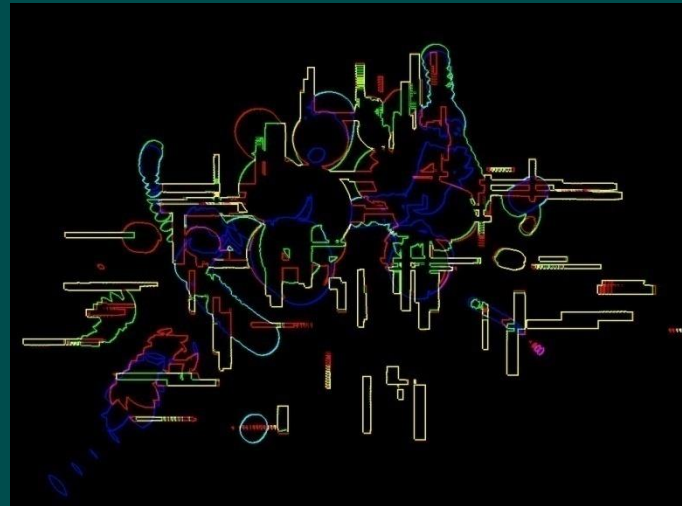
Double Vision

- Collective of dancers, musicians, and media artists
- Free innovation within a particular theme
- First show's theme was DNA
- Installation consisted of Conway's game of Life, audience could add DNA letters as patterns to it, and the generations of cells would trigger music and graphics

Double Vision – Cellspace show

- Steering wheel controllers used in two installations:
  - Art of Driving: drive around and "fire" graphics
  - Bouncing off the Walls: drive around a maze, firing balls, resulting in 4-channel music around you

Movie

DoubleVision – performing graphics

- Red Ink Studio – performing graphics with dancers and musicians

Finger Fresco 2.0

- First attempt at playing music and generating graphics simultaneously in an actual performance

- Used Fingerworks multitouch pads for playing music (same controller built for performing graphics)

- Music keyboard controlled scales/chords

- Notes of the music triggered graphics

- Used at Woodstockhausen 2007

Movie

Galaxy – a Visual Music performance

- New Nothing Theater, part of Visual Music meetup

- Looping music played on a normal keyboard

- Graphics triggered by the notes of the music

- Graphics and music controlled by the "Finger Painting with Planets" controller

- Graphics makes use of Python within a FreeFrame plugin, allowing post-processing of the graphics with other FreeFrame plugins

Movie   Movie

LoopyCam

- Camera-based visual performance instrument

- Performer controls camera position and visual processing with a single integrated device

- First version used a USB webcam, but lighting was always an issue.

- A security camera automatically turns on LEDs in low-light situations.

Movie (Yuri's Night 2010)

Movie (SubZERO 2010)

LoopyCam 2

- LCD display for menus and status

- Number pad (with chording) allows more operations

- Cinder-based application

- Allowed both Freeframe 1.0 and FreeFrame 1.5 (OpenGL)

- LoopyCart – a bike-pulled projector and screen at Burning Man 2010

Returning to Focus on 3D Input

- Fingerworks pads showed the expressive potential
- Third dimension can be:
  - Slider or scroll wheel
  - Pressure (Wacom, Continuum, Eigenharp, Linnstrument, etc)
  - Area (Fingerworks, Magic Trackpad, iPad)
  - Vibration, Orientation, Acceleration (smartphones, joysticks)
  - Spatial (Kinect, Leap Motion, Senz3D)
- 3D input provides natural and expressive input
  - Music: third dimension is useful for vibrato and filters
  - Graphics: very natural for position and size control

3D Input Devices I've explored

- Fingerworks iGesture pad
  - Finger area is the third dimension

- Microsoft Kinect
  - Breakthrough consumer product, structured light

- Leap Motion
  - Mind-blowing resolution   Movie

- Creative / Intel / Senz3D / RealSense
  - Shorter range than Kinect, Time-Of-Flight

- Microsoft Kinect 2
  - Higher-resolution, Time-Of-Flight

- Sensel Morph
  - Multitouch and Pressure-sensitive

Spatial 3D Input – The Pros

- Large movement is enjoyable, engaging, expressive
- Finger dexterity not necessary
- Unified and simultaneous control of all 3 dimensions
- Simultaneous control of multiple continuous values
- Hands-free (e.g. operating room, vehicles)
- Not just hands
 - Full body
  - Object scanning
  - Objects as fiducials

Spacial 3D Input – The Challenges

- Discrete Control
  - Where is the trigger point?
  - Latency, feedback, confirmation
- Gestural Control
  - When to pay attention?
- Tactile feedback
- Controlling one dimension (or finger) independently
  - Latching values
- Reproducibility
- Historical bias and unfamiliarity

Space Palette - a 3D Instrument Interface

- Holes in a frame become 3D multitouch surfaces

- Any number of hands or objects, simultaneously

- Flexible layout allows many control possibilities

- Immediate access to different sounds/graphics

- Provides frame of reference for player and audience

- Larger visual footprint is more interesting to audience

- Immediately playable, no initial dexterity required

- Larger and less-restricted motion by player is relaxing and expressive

Space Palette – Prototypes and Evolution
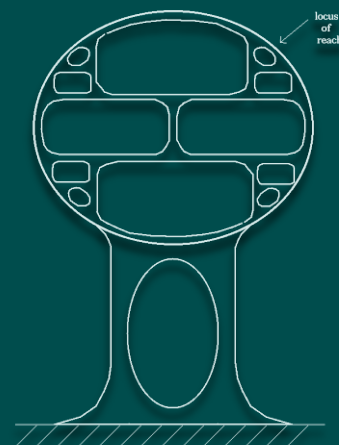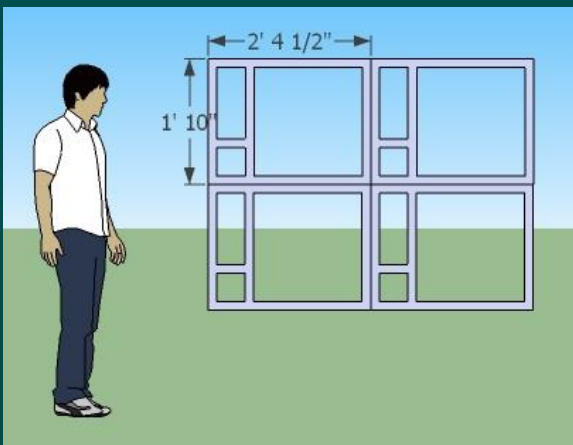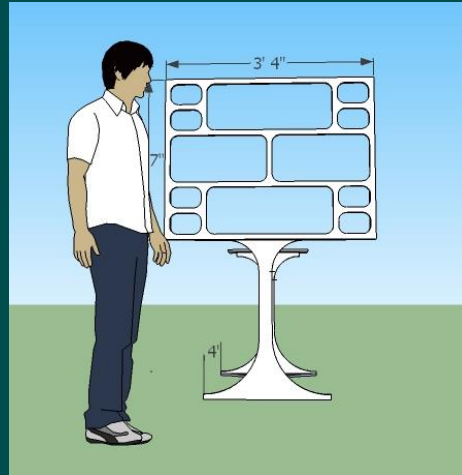
Space Palette Initial Evolution - 2011

- Initial prototype: 4 regions
- More control: 7 regions, 8 buttons
- Lightning in a Bottle   Movie
- West Coast Controller Battle
  - Tennis Ball !   Movie
- Simultaneous graphics using Processing (Java)
- Burning Man 2011   Movie
  - Multi Multi Touch Touch theme camp
- MusicTech Summit, Venice Art Crawl, Decompression, etc

# Space Palette Design - 2011
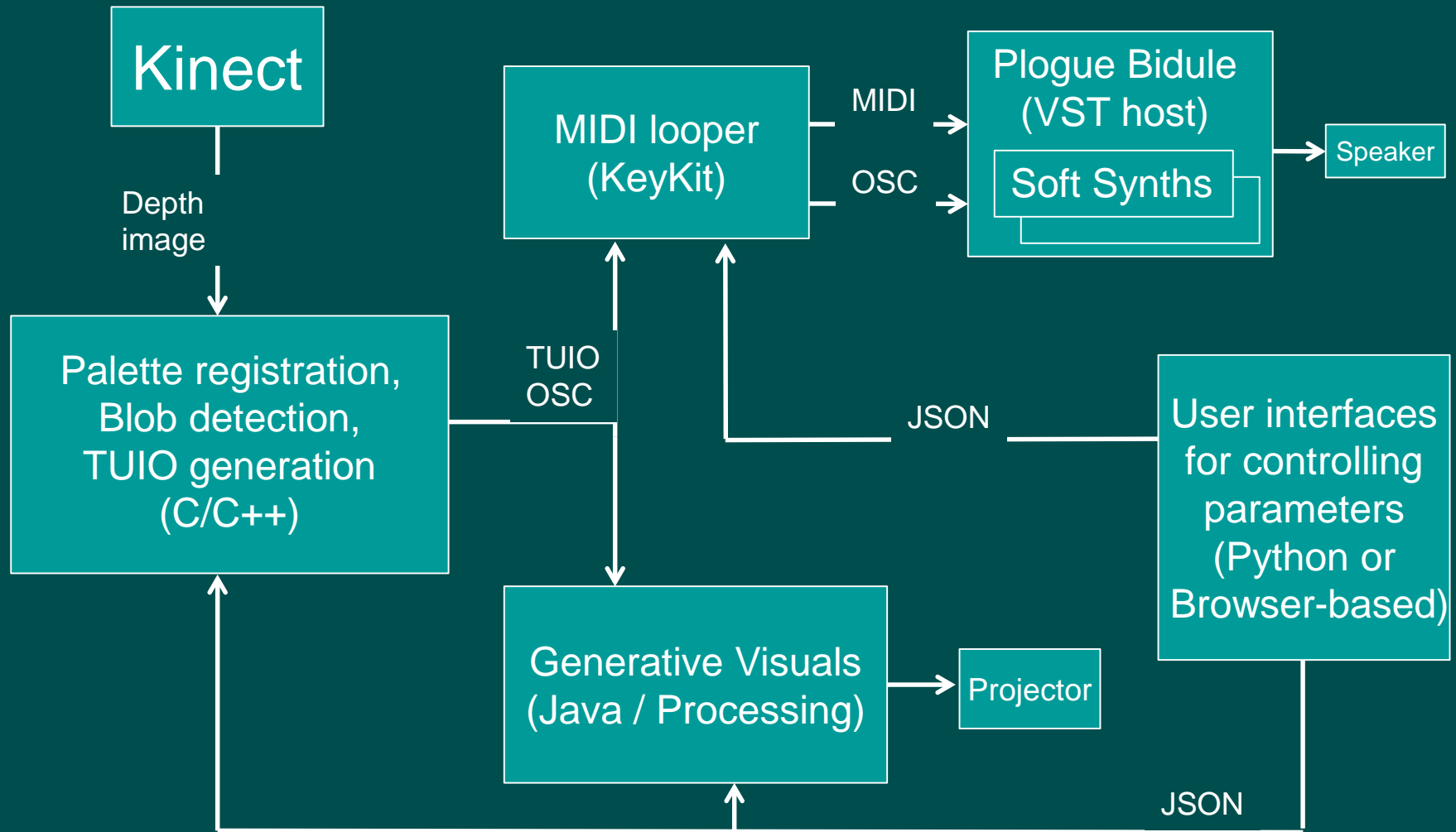
Space Palette Evolution in 2012

- Oval version – 4 regions, 12 buttons

- FreeFrame plugin inside Resolume
  - Eliminates KeyKit and Processing
  - More complex visual effects
  - Resolume can be controlled with OSC
  - HTTP listener, JSON API = browser-based UI for parameter control
  - Single OSC listener and looping mechanism, better synchronization
  - Potential for interaction between graphics and music

- Python integration within FreeFrame plugin
  - Interactive development, more robust error handling
  - Live coding
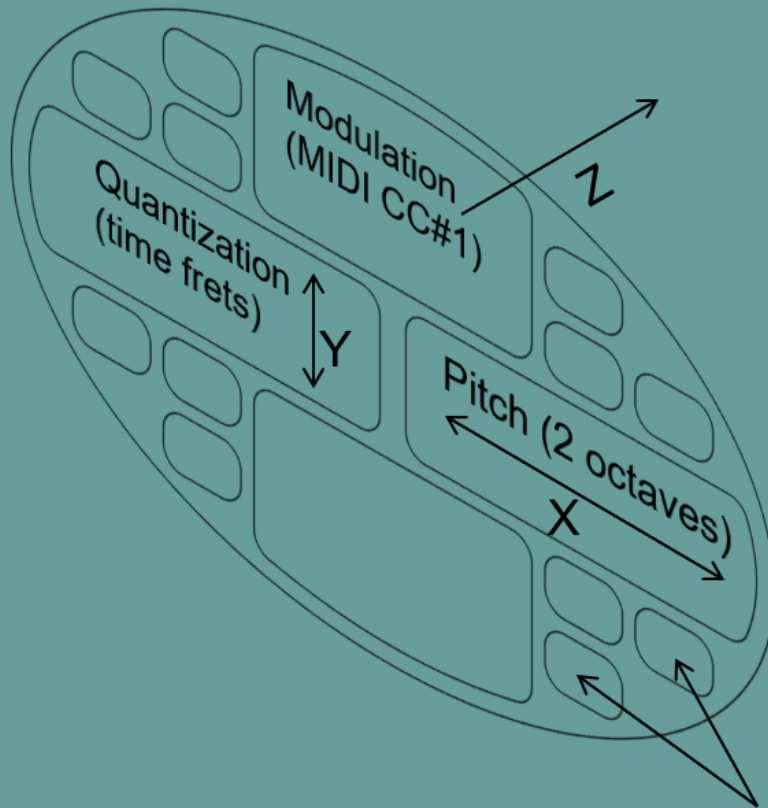 - Easier code sharing and distribution
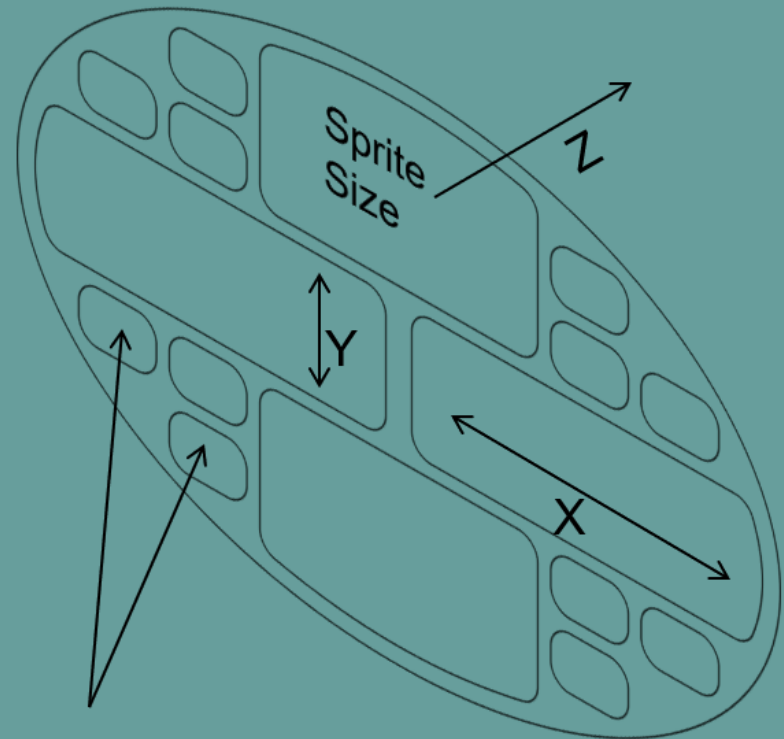
Space Palette Design - 2012
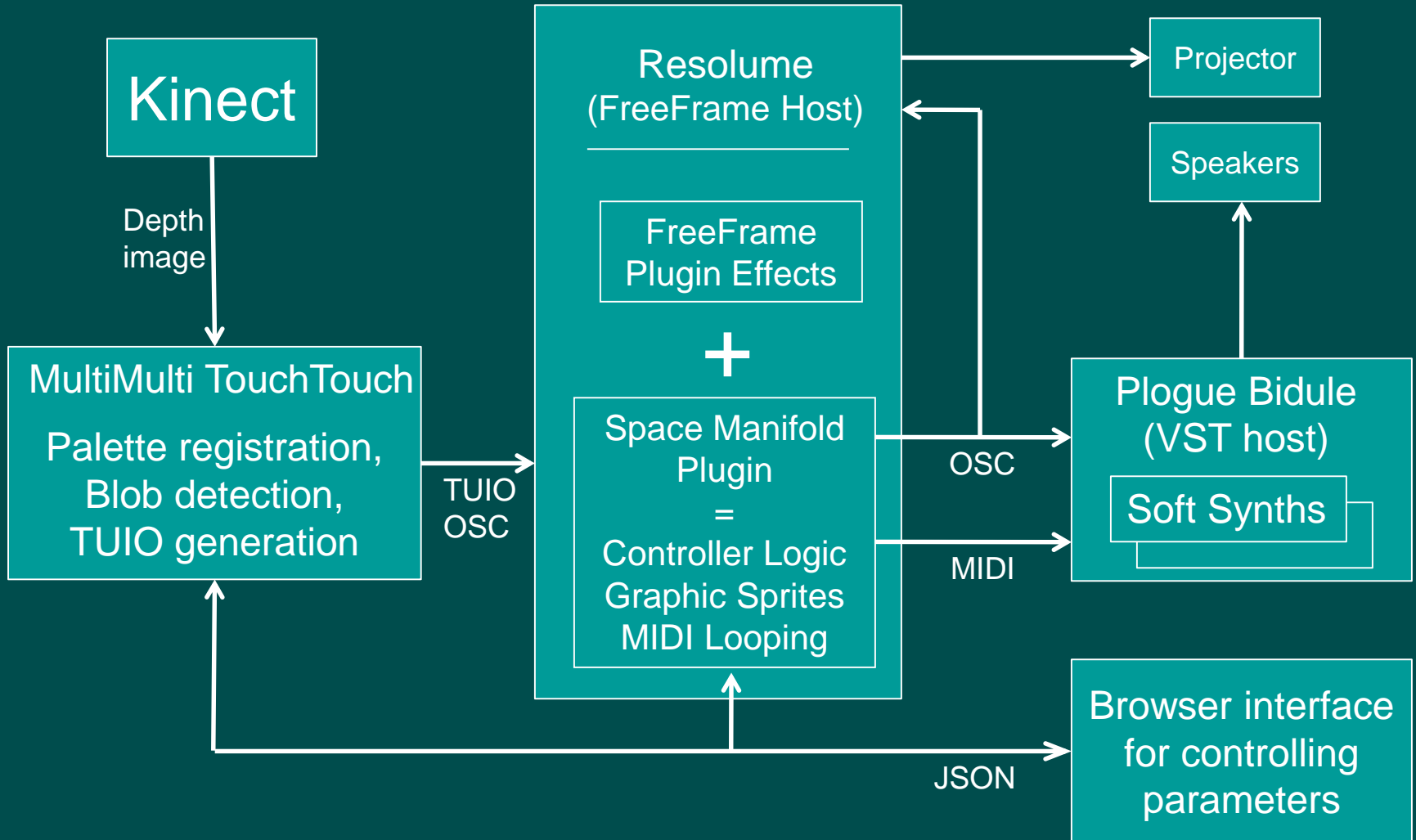
Space Palette Interface

Musical Control

Graphical Control

Quantization
(time frets)

Modulation
(MIDI CC#1)

Z

Y

Pitch (2 octaves)

X

Sprite
Size

Z

Y

X

Each button selects
a different set of sounds
and visual styles for the
four big holes

Controlling the Space Palette

- Presets
  - Small holes are buttons that select presets
- Music
  - Each large hole plays a different sound
  - Horizontal position is pitch, typically two octaves across
  - All notes forced onto a particular scale and key
  - Vertical position controls timing quantization – *Time Frets*
  - Depth is converted to MIDI aftertouch, for vibrato and filters
- Graphics
  - Each large hole is an independent 3D drawing surface
  - Each hole's drawing has independent shape/color/motion
  - Depth controls the size of graphics

Space Palette at Burning Man 2012

Movie

Comments about the Space Palette

- Most common:
    - I want one in my living room.
    - How much? Where can I get one?
    - I could stay here all night.
- Most interesting:
    - Why, it really opens up what an instrument is, right?
    - You gotta try it, you gotta try it, you gotta try it!
    - For those who can't cross that barrier [of playing music], they're literally crossing that barrier [hands reaching through].
    - Gorgeous… and powerful. (from a two-year old girl)
    - I never knew I was a creative person till I walked in there

Where does the Space Palette fit?

- As a Casual Instrument
  - No learning curve: walk up, play, sound good
  - Natural interaction, effortless, engaging
  - Players recognize that they're the ones controlling it
- As a Performance Instrument
  - Physical presence, larger movement, and correlation of actions to output engages the audience
  - Frame of reference allows more and better control
- It's a Floor Wax *and* a Dessert Topping!
  - The choice greatly affects the user interface
  - A single physical interface can serve both

Things Observed and Learned

- Small holes are magnetic

- Musicians know how to rest, listen, and be selective

- Multiple users is fun, but can be confusing

- People love seeing their hands (debugging display)

- The fact that "depth matters" often needs to be explained, but is immediately appreciated

- Time-frets aren't intuitive, but provide useful variety even if you aren't aware of how it works

- Hand motion tendencies may not explore the full range

Space Palette Evolution in 2013

- Short-range 3D input using Creative Senz3D
  - Smaller Space Palette, single-person use
  - More practical for the living/family room
  - Multiple Palettes = Space Orchestra
- Burning Man 2013
  - 4 single-user Space Palettes   Movie
- Discovery
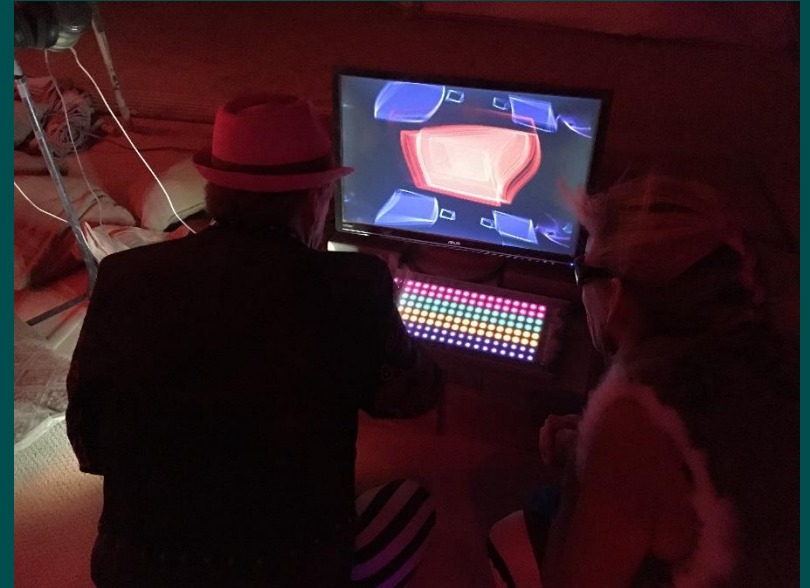 - Larger physical motion is more enjoyable and engaging

Space Palette Evolution in 2014

- Golden aspect ratio
- Matching oval monitor frame
- Burning Man 2014

UniLooper

- Looping instrument for Visual Music
- LinnStrument used as the input device   **Movie**
- Performance at Looping Festival in 2015   **Movie**
- Photon Salon - Burning Man 2016

Sensel Morph - a dream come true for 3D input

- 20,000 force-sensing resistors, detects 5g to 5kg

- Raw data is easily obtained

- Overlays for different control layouts
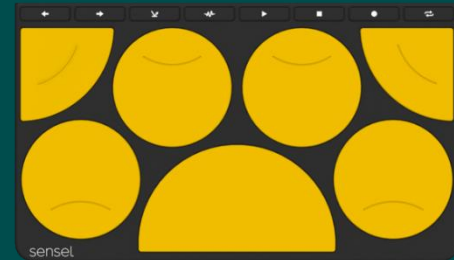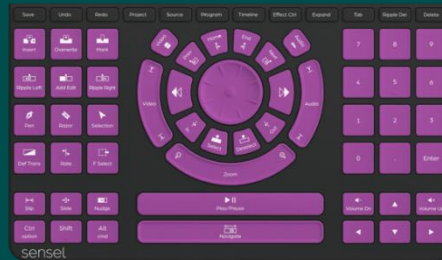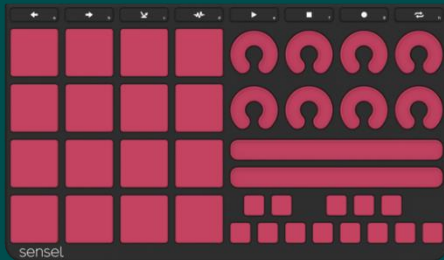
- Magnets in overlays allow detection and swapping

- No overlay == blank canvas

Space Palette Pro

[Movie](#)

- 4 Sensel Morphs and a touchscreen

- Third dimension is pressure

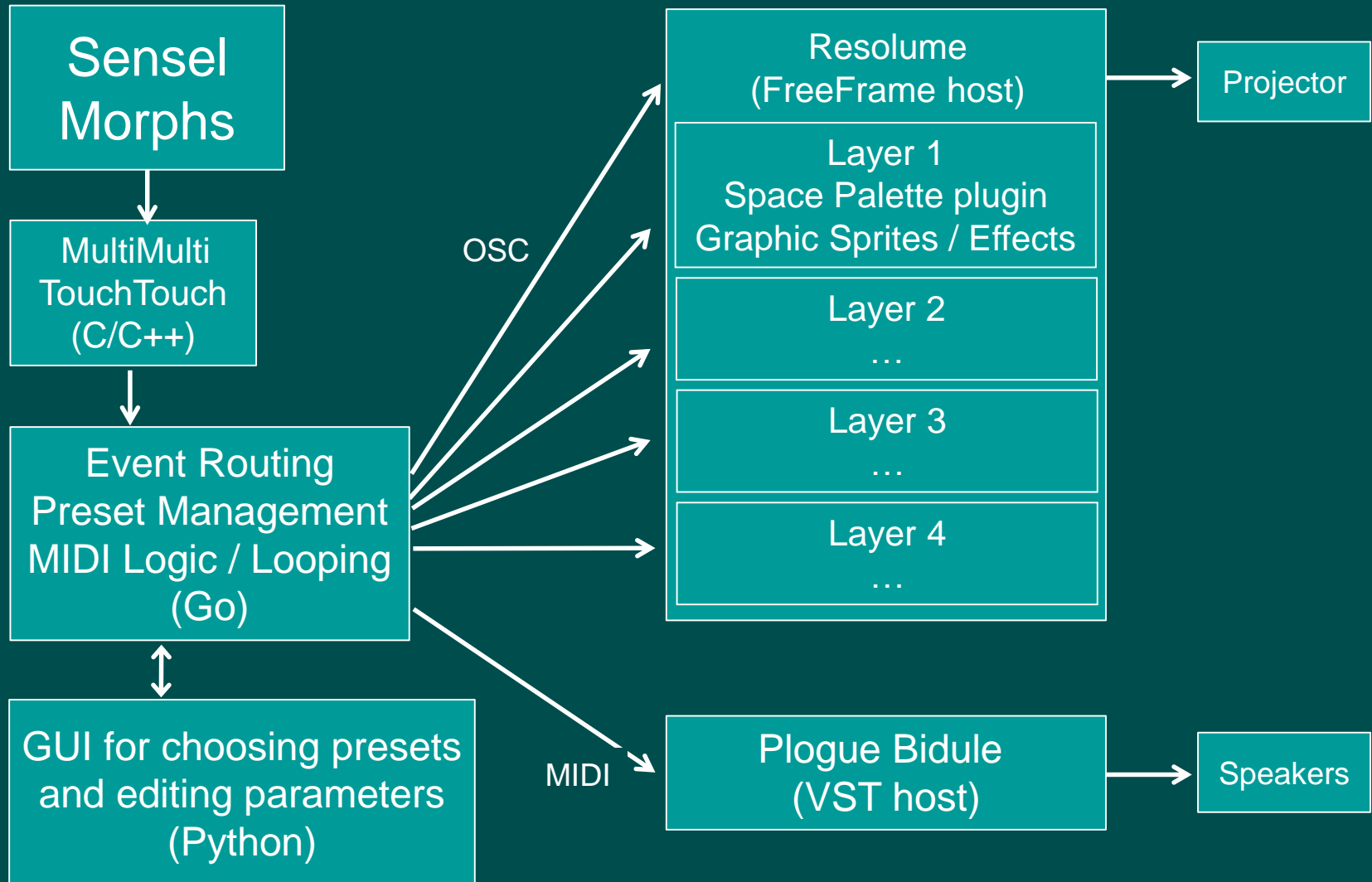- One 3D cursor per finger (rather than per hand)

Space Palette Pro in 2018

- Software very similar to the original Space Palette
  - Using TUIO protocol for 3D cursors made porting trivial
- Evolution toward a performance instrument
  - Each pad can be controlled independently
  - Looping of gestures = looping of both music and graphics
  - External MIDI keyboard can adjust scale dynamically
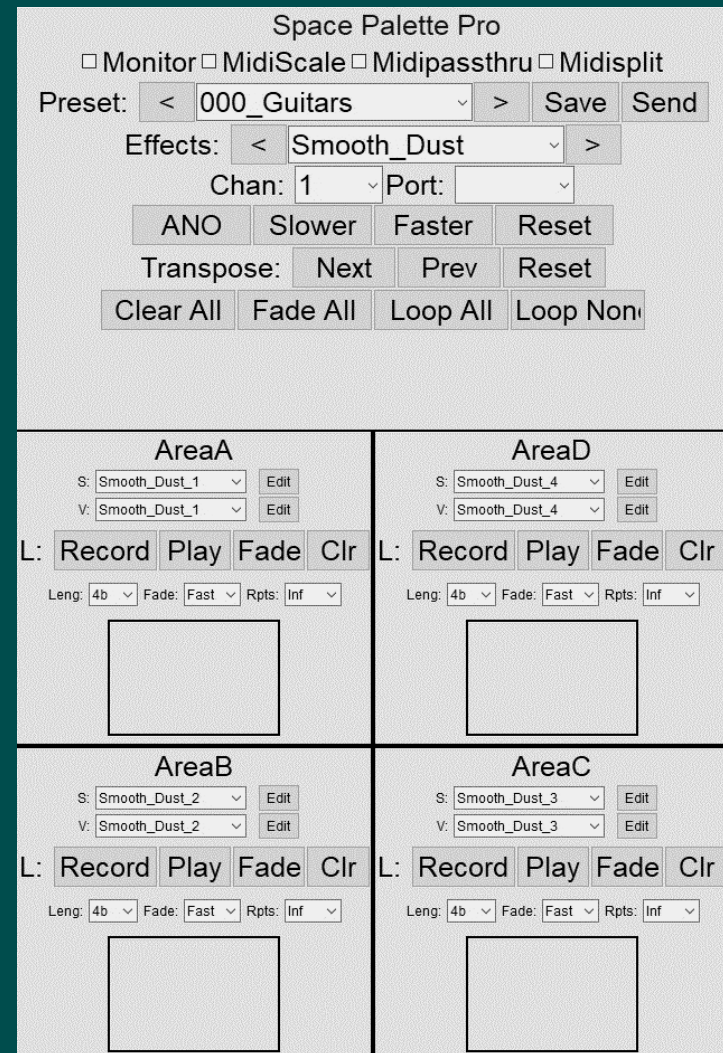- Solo performance at the Outsound New Music Summit

Space Palette Pro in 2019

- Independent visual effect layers for each Morph
  - Four instances of Space Palette plugin in Resolume
  - Greatly increased visual variety
- Python-based GUI for preset selection and editing
- Go-based router
  - Handles all input - TUIO, MIDI, APIs
  - Generates MIDI output
  - Realtime looping
  - Recording and playback of all input
  - APIs for parameter and preset control (used by GUI)

Space Palette Pro Design - 2019

Space Palette Pro GUI – Casual vs Performing

Presets

All Drums	Basic Chaos	Bellsy Bells	Bold Strokes
Complex Kaleid	Deep Triangles	Dream Puddles	Drifting Borders
Dusty Pools	Edgy Kaleid	Endless Colors	Explosive Shapes
Full Bodied	Ghost Puddles	Line Dance	Organic Growth
Perky Trails	Plucky Stuff	Shape Shards	Simple Organisms
Smooth Breathing	Smooth Dust	Spiro Graphical	Too Square

Actions

Looping OFF	Length 8 Beats	Fast Fade	Clear Loops
Default Scale			Reset All

Space Palette Pro

☐ Monitor ☐ MidiScale ☐ Midipassthru ☐ Midisplit

Preset: [<] 000_Guitars [>] [Save] [Send]

Effects: [<] Smooth_Dust [>]

Chan: [1] Port: [ ]

[ANO] [Slower] [Faster] [Reset]

Transpose: [Next] [Prev] [Reset]

[Clear All] [Fade All] [Loop All] [Loop None]

AreaA
S: Smooth_Dust_1 [Edit]
V: Smooth_Dust_1 [Edit]
L: [Record] [Play] [Fade] [Clr]
Leng: [4b] Fade: [Fast] Rpts: [Inf]

AreaD
S: Smooth_Dust_4 [Edit]
V: Smooth_Dust_4 [Edit]
L: [Record] [Play] [Fade] [Clr]
Leng: [4b] Fade: [Fast] Rpts: [Inf]

AreaB
S: Smooth_Dust_2 [Edit]
V: Smooth_Dust_2 [Edit]
L: [Record] [Play] [Fade] [Clr]
Leng: [4b] Fade: [Fast] Rpts: [Inf]

AreaC
S: Smooth_Dust_3 [Edit]
V: Smooth_Dust_3 [Edit]
L: [Record] [Play] [Fade] [Clr]
Leng: [4b] Fade: [Fast] Rpts: [Inf]

Space Palette Pro - GUI Evolution in 2019

Space Palette Pro at Burning Man 2019

- Photon Salon

- PlayAlchemist Grand Pyramid

Movie

Future Direction Possibilities

- ISF (Interactive Shader Format) instead of FreeFrame
- Graphics generation in Go
  - Use Spout to send to Resolume (or other visual host)
- More interesting finger painting behaviour
  - Two-handed control
  - Pressure semantics
- More interesting musical behavior
  - Phrases rather than notes
  - Scanning sequences

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These slides can be found at https://timthompson.com/talks

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