3D Input
A New Dimension in Control

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Outline

- Recent and new 3D input devices

- Features, uses, pros, cons

- My use of 3D input

  - Fingerworks iGesture pad

  - Leap Motion

  - Kinect (Space Palette)

- Casual versus performance instruments

- Things observed and learned

Entering the Third Dimension

- Screen pointing devices are mostly 2D
- 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)
- Recent breakthroughs and popularity in Spatial 3D
  - Fab or Fad?
  - Highly dependent on application

3D Input Devices – Recent/New Products

- Fingerworks iGesture pad (no longer produced)

- iPad, Magic Trackpad (not widely recognized)

- Microsoft Kinect (PrimeSense)

  – Kinect 2 coming in 2014

- Leap Motion

- Intel/Creative Senz3D (aka SoftKinetic 325)

Spatial 3D Input

- 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

3D Input 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

Controlling Media with 3D Input

- Graphical Control
    - 3D position (only natural with some 3D input devices)
    - Size is very natural and expressive
    - Color, alpha, angle, speed, distortion
    - Video mixing, playback speed
- Musical Control
    - Vibrato, tremolo, LFO speed
    - Filter, brightness, distortion
    - Timing quantization
    - Audio mixing, playback speed, front/rear position

3D Input Devices – My Approach

- Build casual instruments as interactive installations
    - Artwork where people create art rather than consume art
    - Obvious correlation between action and result
- Avoid things that are problematic
    - Add latency (quantize) rather than focus on reducing it
    - Use depth map only (skeleton tracking is easily disrupted)
- Introduce a physical reference
    - Improves amount of control (both perceived and actual)
    - More input areas, each one an independent instrument
    - Improves audience engagement and understanding

3D Input Device - iGesture pad

- **`www.fingerworks.com`**

- Inexpensive multi-touch pad

- Excellent responsiveness

- Event data: x, y, proximity, eccentricity, orientation, contacts, device, finger, hand, xvelocity, yvelocity

- Multiple pads can be used simultaneously

- Apple bought the company in 2005 and took the product off the market ☹

- Technology and expertise used in iPhone

A Custom Controller for Performing Graphics

- Fingerworks iGesture pads
  - Multitouch with area-detection
  - Extremely responsive

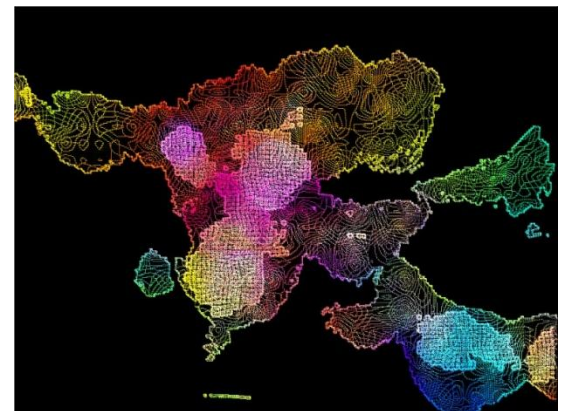# Uses of Fingerworks iGesture pads

- Finger Fresco at Maker Faire 2007

Movie

Finger Painting with Planets

- Maker Faire 2008

DoubleVision – performing graphics

- Red Ink Studio – performing graphics with dancers and musicians

3D Input Device - Leap Motion

- Extremely precise and fast

- Designed for finger and hand detection

- Close range – within a 2 foot cube

- Over 10,000 developers have early access

- Shipping soon

MidiFingers – a Leap Motion experiment

- Horizontal dimension controls pitch

- Vertical dimension controls timing quantization

- Depth (3rd) dimension controls volume/brightness

- Real-time control of musical scale

  - Press the notes of a chord/scale on a MIDI keyboard

  - Notes played with Leap are forced onto that chord/scale

- Python source code

  - `http://github.com/nosuchtim/midifingers`

3D Input Device – Microsoft Kinect

- Fastest-selling consumer electronics device ever

- Inexpensive and ubiquitous

- Good resolution and robustness

- Easy to access from custom software

- Can be used as a 3D scanner

- Tolerant of dust, intolerant of sunlight

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 - Evolution and Variations
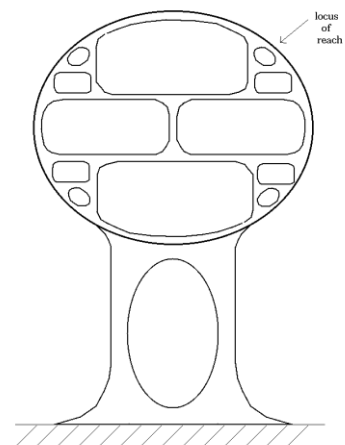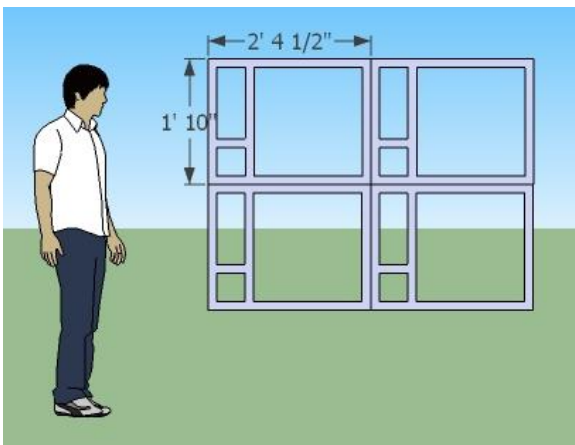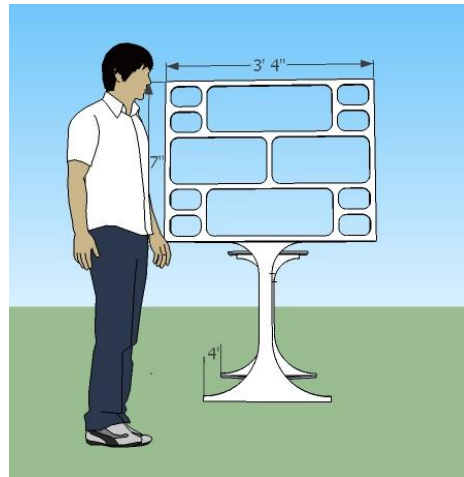
Controlling the Music

- Each large hole plays a different sound

- Horizontal position is pitch
    - All notes forced onto a particular scale and key
    - Typically two octaves across

- Vertical position controls timing quantization - "time frets"
    - Three bands: one beat, half-beat, quarter-beat

- Depth position:
    - Converted to MIDI aftertouch, used for vibrato, filtering, and mixing

- Small holes are buttons
    - Performance UI - change key, scale, sounds, looping
   - Casual UI – select presets

Controlling the 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
- Small holes are buttons
    - Performance UI - change color, shape, motion
    - Casual UI – select presets

Space Palette Interface

Musical Control

Graphical Control

Modulation (MIDI CC#1)

Quantization (time frets)

Pitch (2 octaves)

Sprite Size

Z

Y

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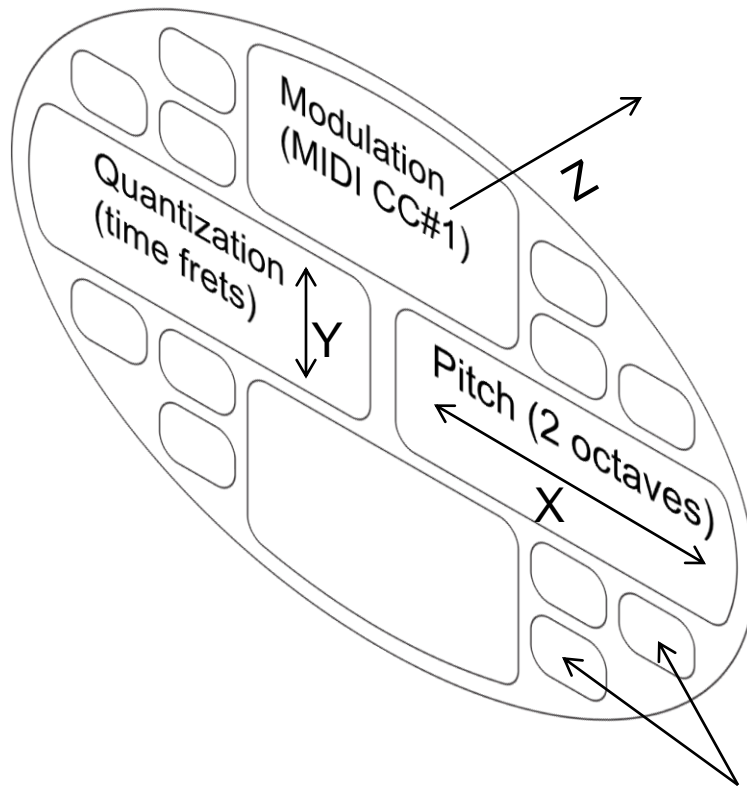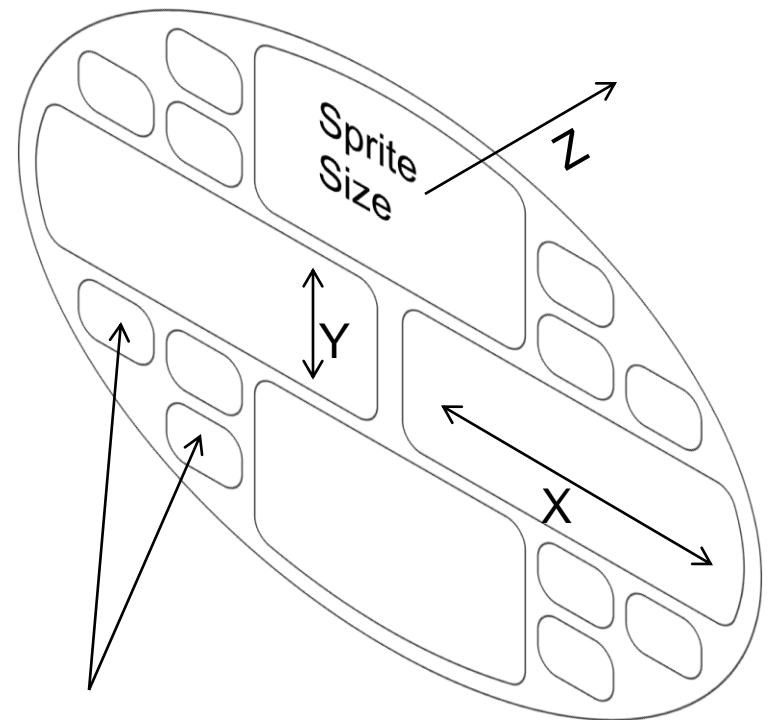
Each button selects
a different set of sounds
and visual styles for the
four big holes

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)

Types of Instruments

- Casual Instruments
  - Prioritize fun and enjoyment
  - Few or no instructions
  - Immediate gratification, no learning curve
  - 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

Where does the Space Palette fit?

- **As a Casual Instrument**
  - No learning curve: walk up, play, sound good
  - Natural interaction, effortless, engaging
  - Control over individual notes
  - Players recognize that they're the ones controlling it

- **As a Performance Instrument**
  - Physical presence is more visible and entertaining
  - Performer's larger movement engages the audience
  - More obvious correlation of physical actions to output
  - Frame of reference allows more and better control

Where does the Space Palette fit?

- Both casual and performance?
  - User interface is greatly affected by the choice
  - A single physical interface can serve both
- Casual use is the current sweet spot
  - Confirmed by several years at Burning Man and other events
  - UI continues to be simplified, visual feedback added
- Performance use has been explored
  - Several solo and collaborative performances
  - Several UI style experiments (e.g. shift-select style)
  - Open source MultiMultiTouchTouch allows others to explore

Things Observed and Learned

- Casual use vs. performance use influences the design a lot

- Small holes are magnetic

- Labels are rarely read

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

    – They aren't the only ones who can do those things

- Looping can be confusing

- Multiple users is fun, but can be confusing

More Things Observed and Learned

- Correlation of graphics to hands is often not noticed due to extreme visual effects

- People love seeing their hands (debugging display)

- Effect of depth 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 limit the pitch range used:
  - Depth-only with no up-down or left-right motion
  - Up-down with no left-right motion

Initial Evolution - 2011

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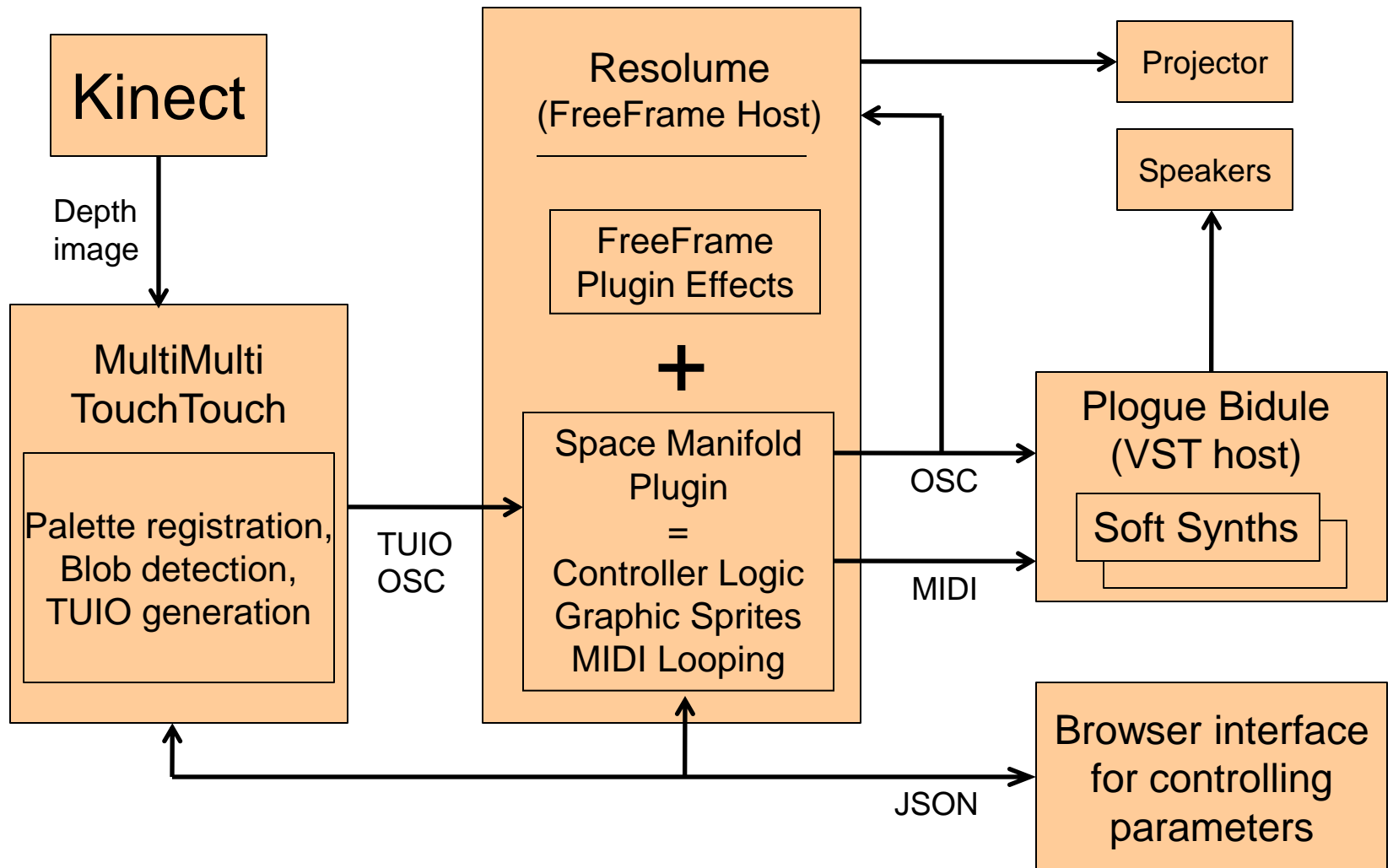- MusicTech Summit, Venice Art Crawl, Decompression, etc

Design - 2011
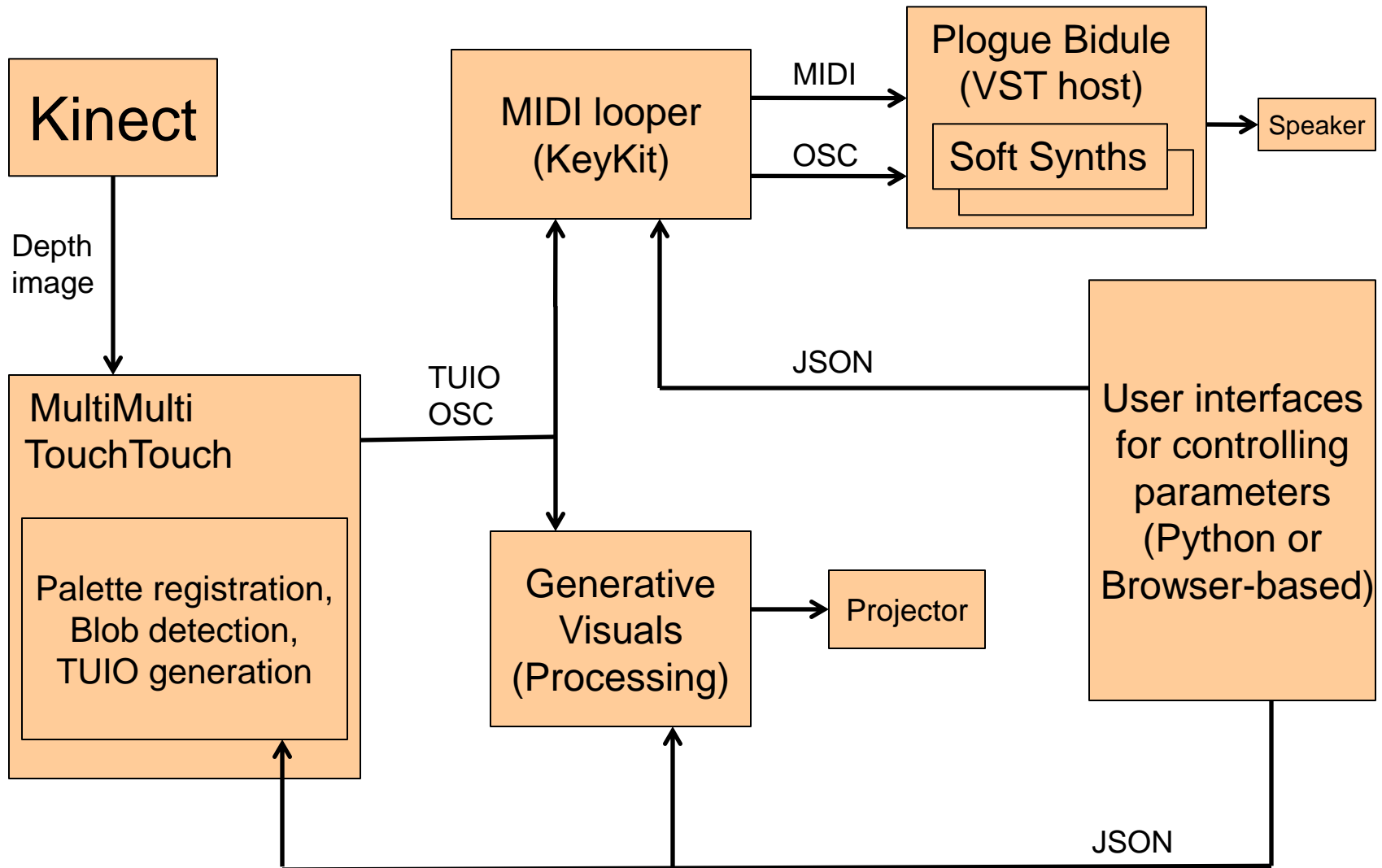
Recent Evolution - 2012

- Oval version – 4 regions, 12 buttons
- FreeFrame plugin inside Resolume
  - Eliminates KeyKit and Processing
  - More complex visual effects using other FreeFrame plugins
  - 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

Design - 2012

Kinect

Depth image

MultiMulti TouchTouch

Palette registration, Blob detection, TUIO generation

TUIO OSC

Resolume (FreeFrame Host)

FreeFrame Plugin Effects

+

Space Manifold Plugin = Controller Logic Graphic Sprites MIDI Looping

OSC

MIDI

Projector

Speakers

Plogue Bidule (VST host)

Soft Synths

Browser interface for controlling parameters

JSON

What's new for 2013?

- **Short-range 3D input**
  - Smaller Space Palette, single-person use
  - More practical for the living/family room
  - Multiple Palettes = Space Orchestra
- **Time-Of-Flight cameras**
  - Microsoft moving to TOF
  - Intel/Creative/Softkinetic is TOF
  - Higher resolution?

Software

- MMTT (MultiMultiTouchTouch)

- Resolume (FreeFrame host)

  - Projection mapping and visual effects

- Space Manifold (FreeFrame Plugin)

  - Receives TUIO/OSC, generates graphics AND music

  - Looping mechanism

- Plogue Bidule (VST host)

- VST Soft Synthesizers

  - Battery 3, Alchemy

- Browsers (local and remote)

  - User interface (and JSON API) to control MMTT, Space Manifold

MultiMultiTouchTouch (MMTT)

- C++ program uses libfreenect to talk to Kinect

- Uses depth image only

- Blob detection using OpenCV

- Trainable interactively on new frames, holes of any shape

- Trainable without a frame, using a specially-colored image

- Browser interface to control it, using JSON over HTTP

- Output is TUIO (a standard multitouch format) over OSC (a standard UDP protocol)

- Windows-only, source code freely available:
  ```
  http://multimultitouchtouch.com/dist
  ```

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