



# **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, Senz3D (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 Sens3D (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](http://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



# Other uses of Fingerworks iGesture pads

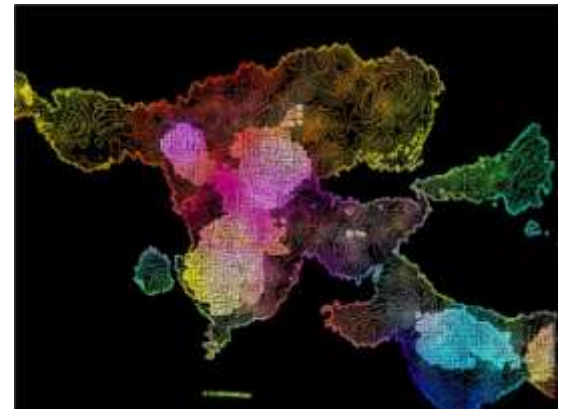
- Finger Fresco at Maker Faire 2007



[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
- Not a general-purpose 3D camera

# MidiFingers – a Leap Motion experiment

- Horizontal dimension controls pitch
- Vertical dimension controls timing quantization
- Depth (3<sup>rd</sup>) 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

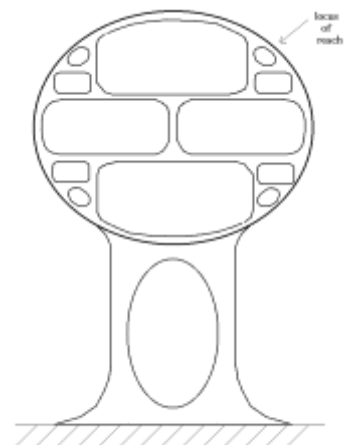
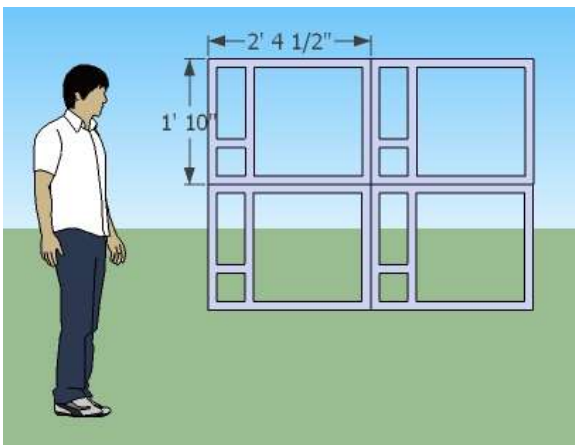
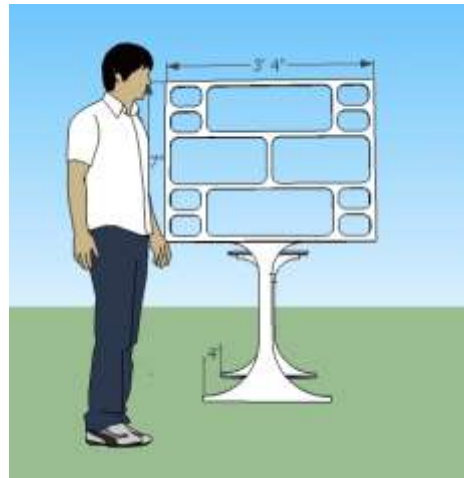
- Fastest-selling consumer electronics device ever
- Inexpensive and ubiquitous
- Good resolution and robustness
- Easy to access from custom software
- Can be used as a 3D scanner
- Tolerant of dust, intolerant of sunlight



# 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

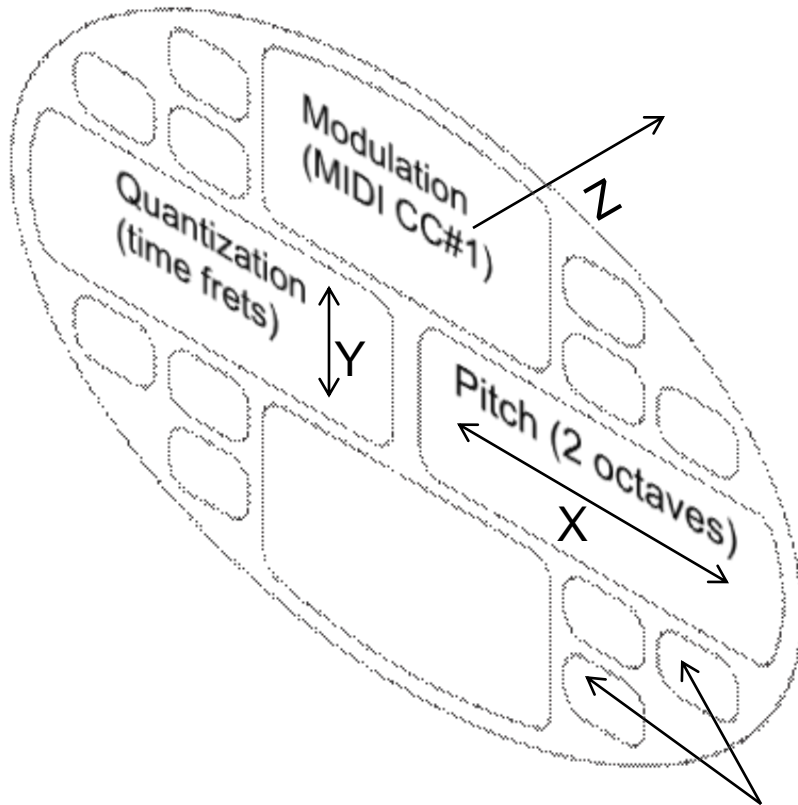
- Each large hole plays a different sound
- Horizontal position is pitch
  - All notes forced onto a particular scale and key
  - Typically two octaves across
- Vertical position controls timing quantization - “time frets”
  - Three bands: one beat, half-beat, quarter-beat
- Depth position:
  - Converted 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

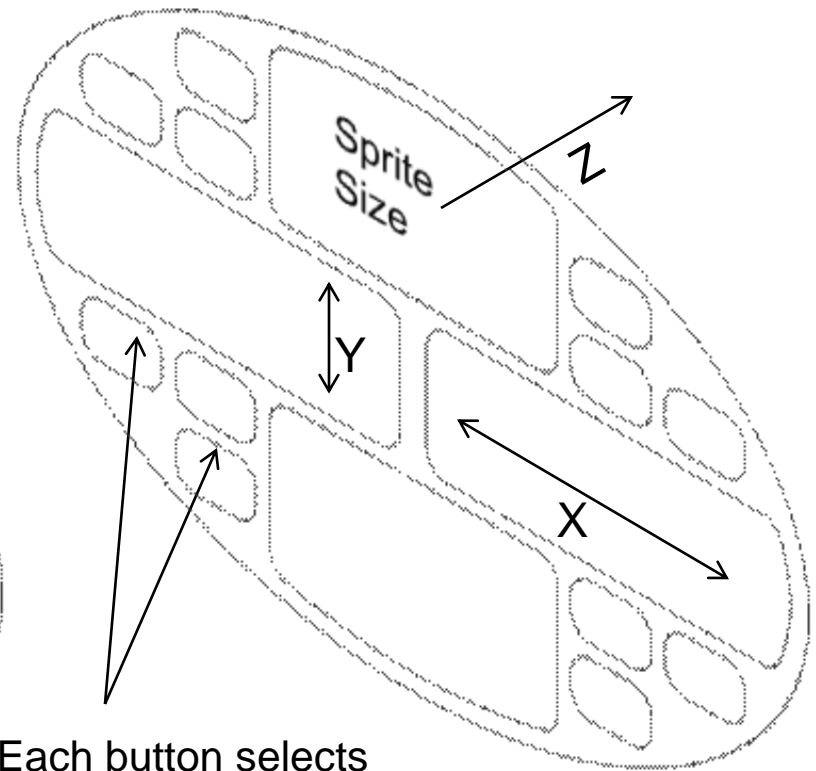
- Each large hole is an independent 3D drawing surface
- Each hole's drawing has independent shape/color/motion
- Depth controls the size of graphics
- Small holes are buttons
  - Performance UI - change color, shape, motion
  - Casual UI – select presets

# Space Palette Interface

Musical Control



Graphical Control



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

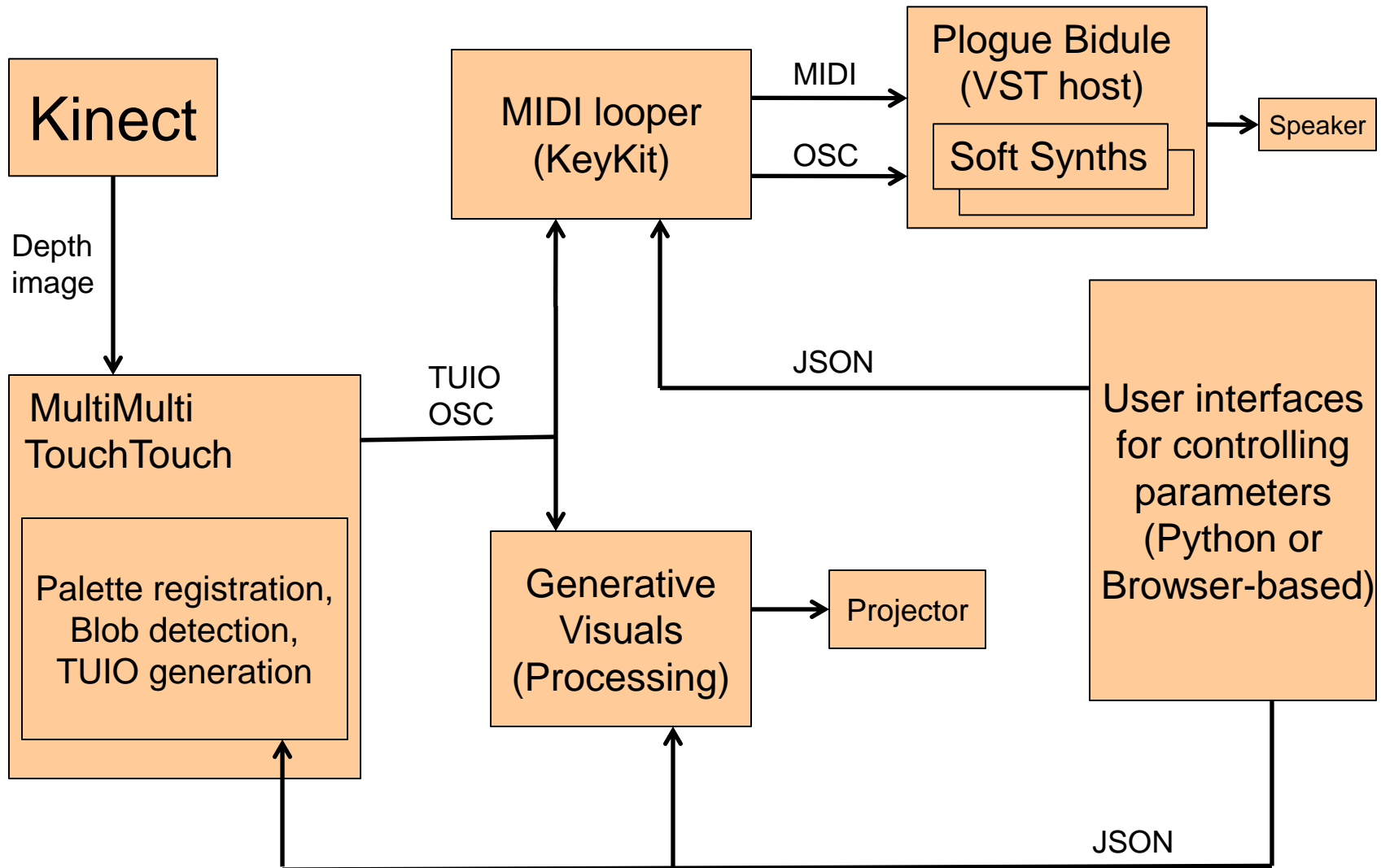
# More Things Observed and Learned

- 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

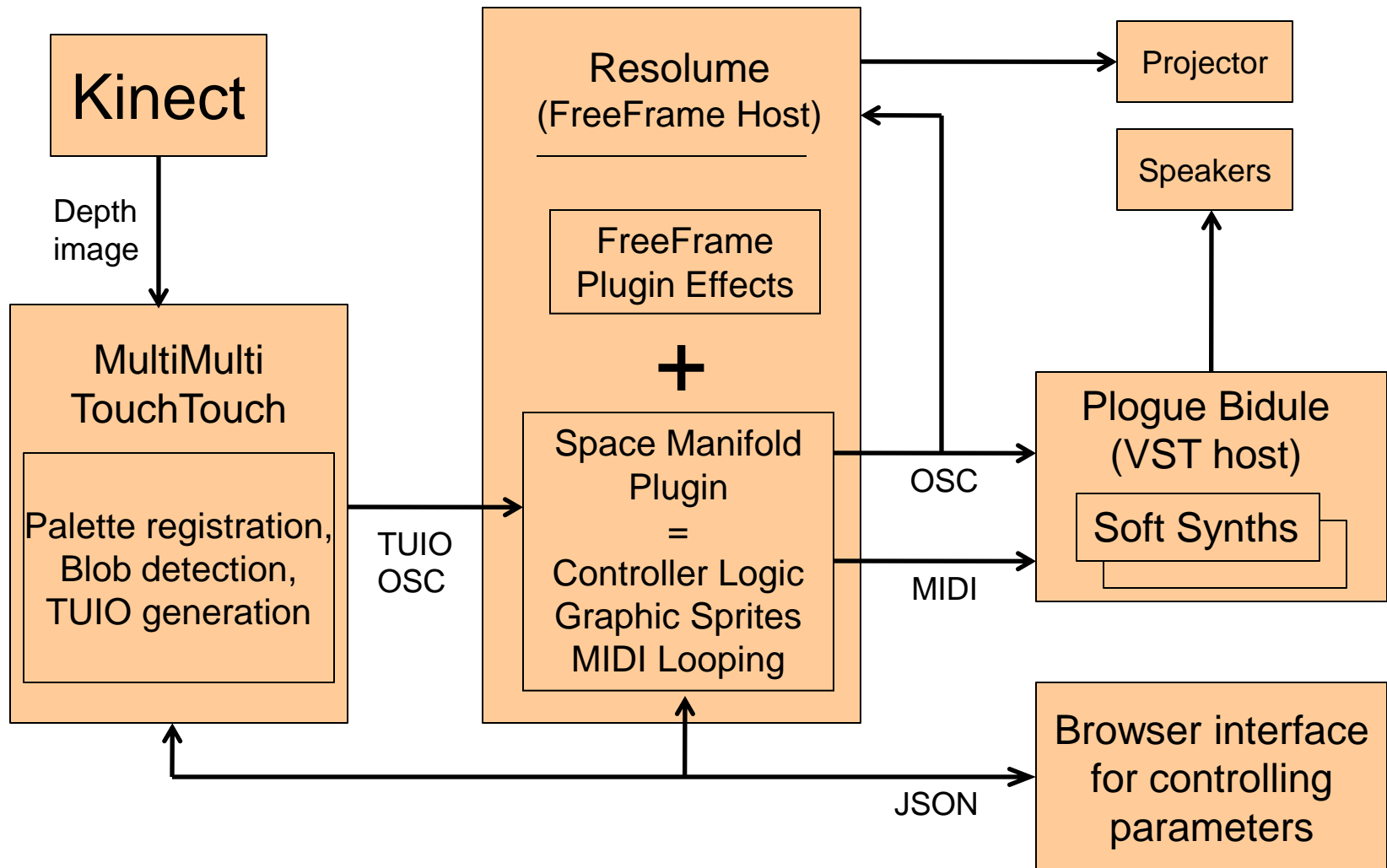
# Design - 2011



# Evolution in 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 to present



# New in 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 (Kinect 2)
  - Intel/Creative/Softkinetic is TOF (Senz3D)
  - Confidence Map



# New in 2014

- New Base, Golden Ratio, Monitor Frame



# San Jose Tech Museum



[movie](#)

# 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, supports Kinect, Kinect 2, and Senz3D
- 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, open source:

<http://multimultitouchtouch.com>



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