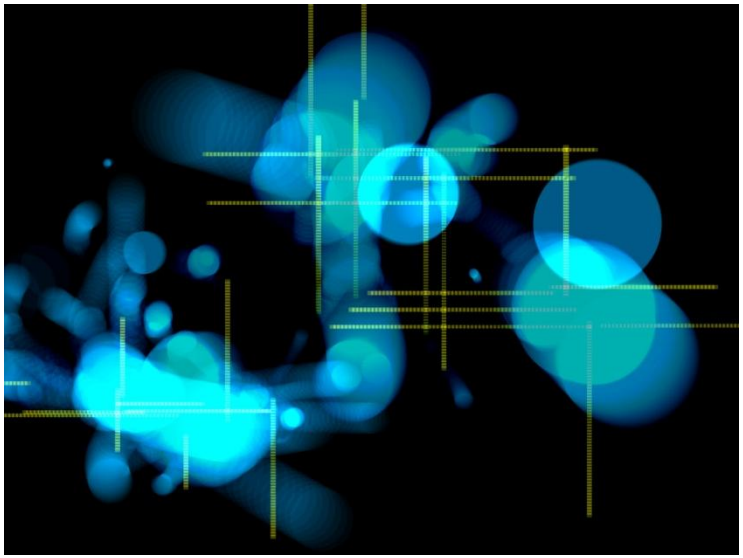
Finger Painting with Planets



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What is it?

- Installation for people to play with
- Generates music and graphics simultaneously
- Controller with buttons, knobs, LCD, multitouch pad
- Fingers on multitouch pad trigger music or graphics
- Graphics motion is simulated gravitational attraction
- Collisions of planets trigger music
- Musical keyboard controls (only) selection of notes

Appearances

- Yuri's Night 2008
- Maker Faire 2008
- Night Light at Climate Theater
- Anon Salon at Climate Theater
- SubZERO street fair, ZERO1 Festival
- Starry Night at Villa Montalvo
- Burning Man 2008

User interface was adjusted/simplified each time

Big Pieces

- KeyKit – input and realtime processing
- Plogue Bidule – VST host for sounds
- Salvation – Freeframe host for visuals
- Planets – Freeframe plugin (embedded Python)
- Cairo – drawing on bitmap (from Python)
- Chipmunk – Physics simulation (from Python)
- OpenCV – raster manipulation (from C)
- OSC – communication between KeyKit and Planets

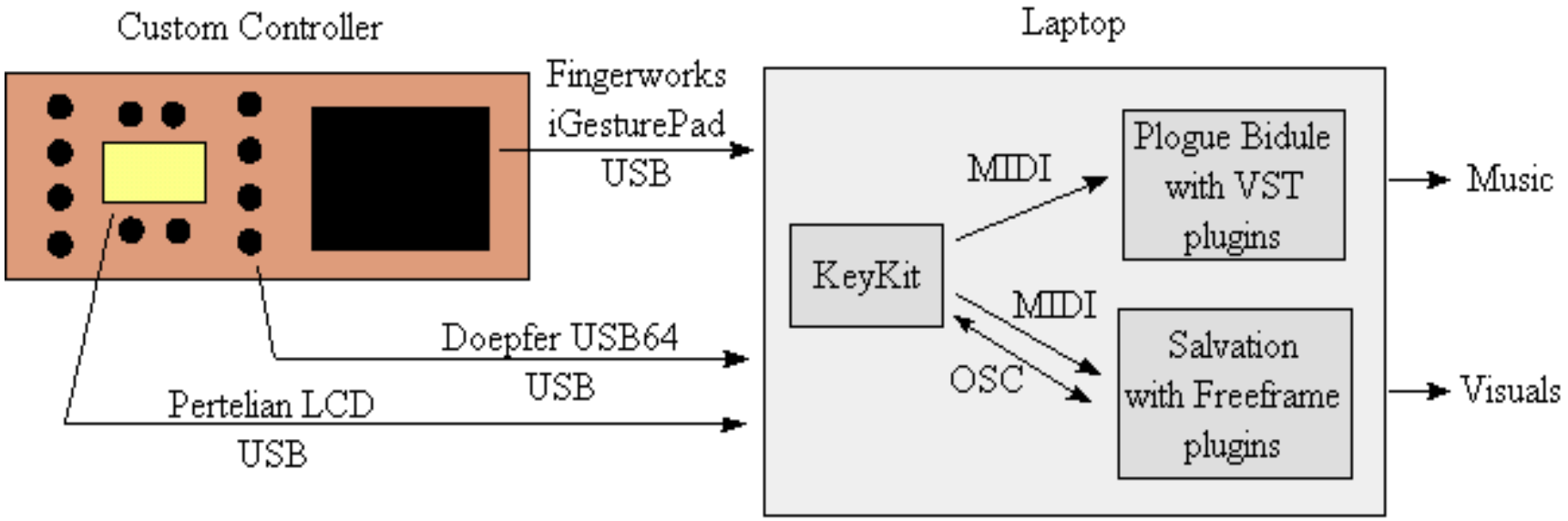
A Mashup without the Web

- Re-using and combining large pieces of software
- Explosion of large pieces of freely available code
- Protocols and mechanisms are relatively standardized
- Good separation of functionality
- APIs are now front and center
- Ease of integration is getting better
- Requires care in selection, one bad apple...

Multiple Languages

- Attempted to avoid it, now embraced
- Each language has pros/cons in:
  - Library availability
  - Device I/O availability
  - Robustness
  - Ease of Development
  - Familiarity
  - Expense

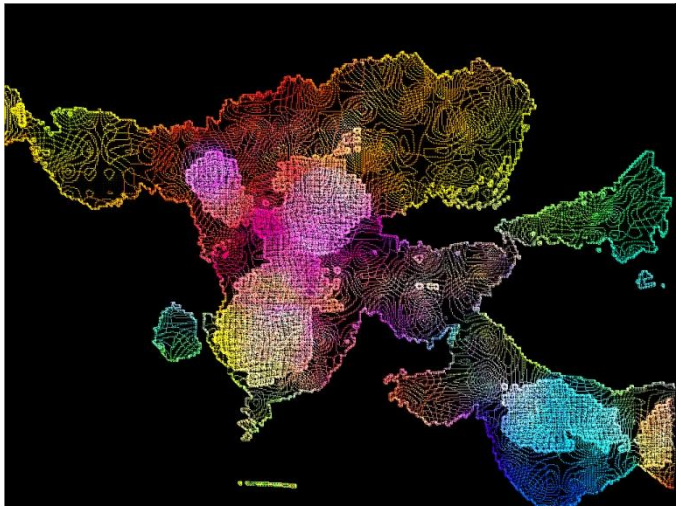
What's connected to What

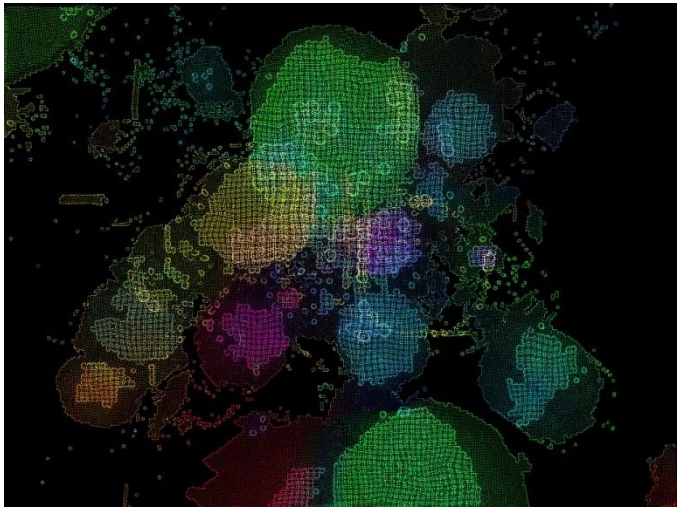


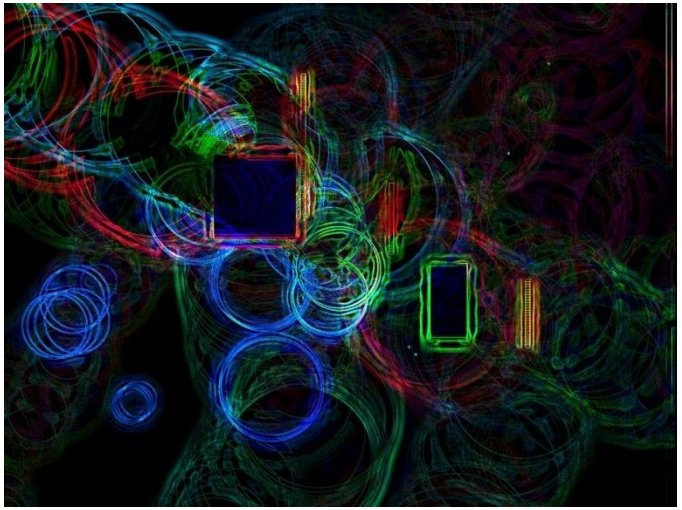
Custom Controller

Controllers In Use

Examples of Visual Output







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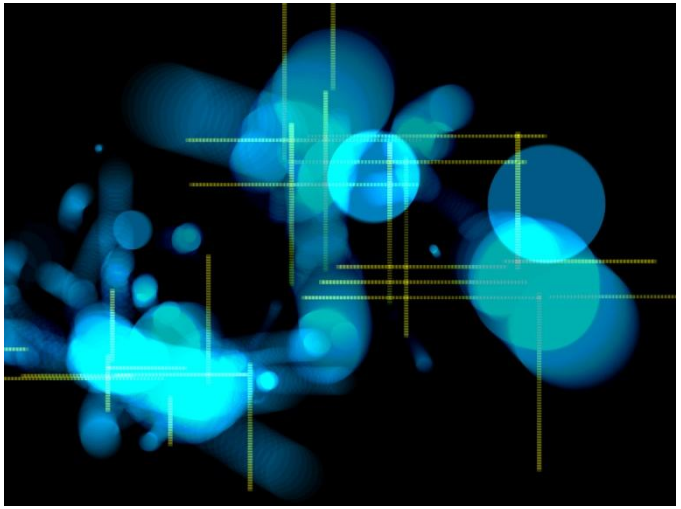

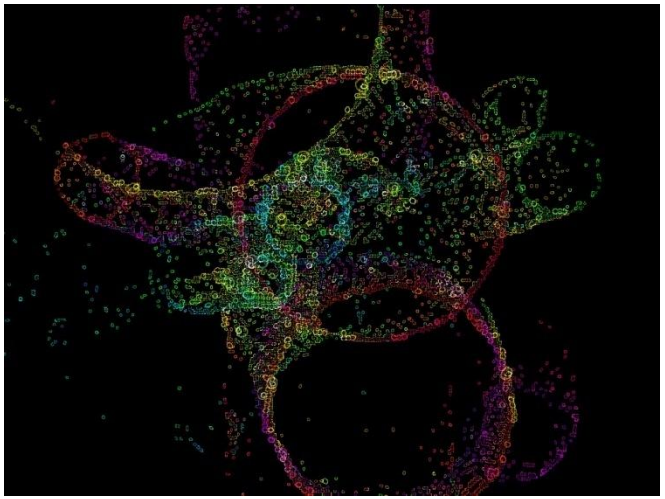

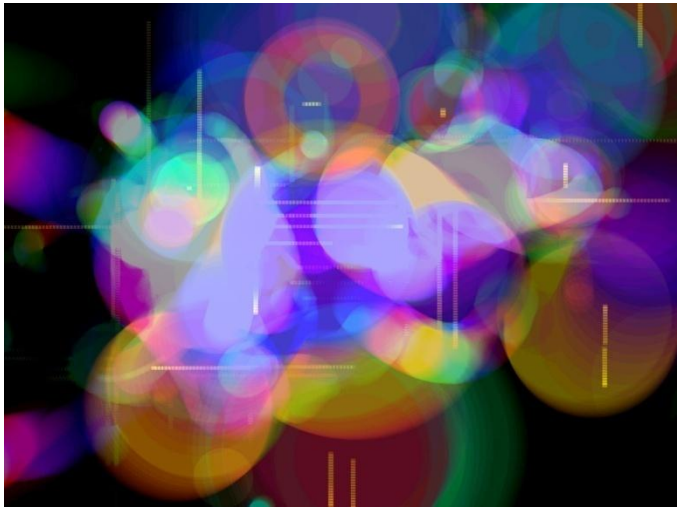

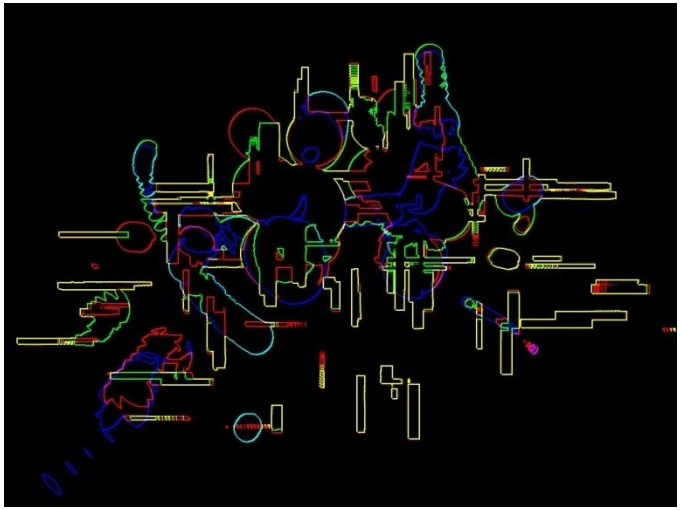

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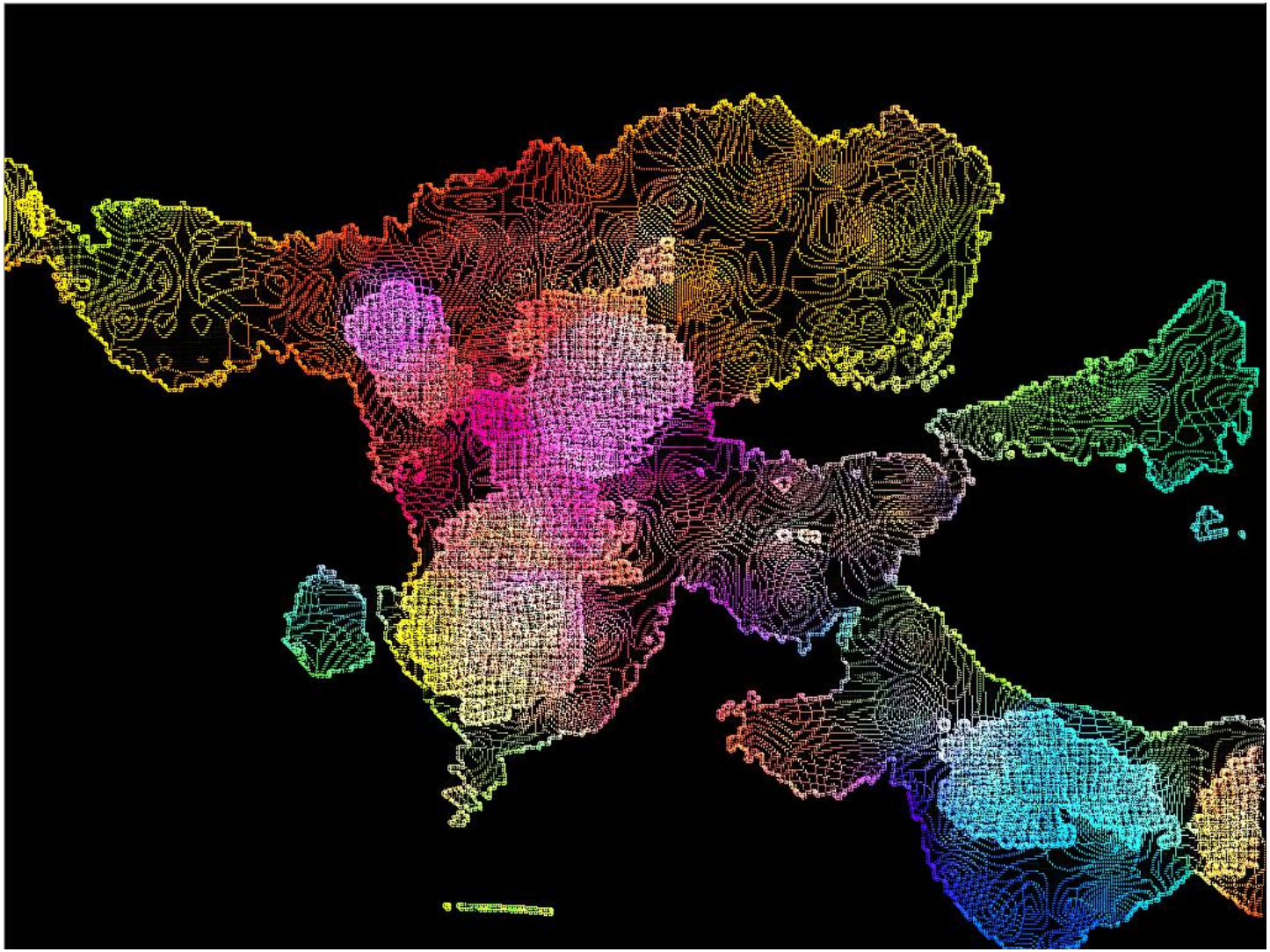

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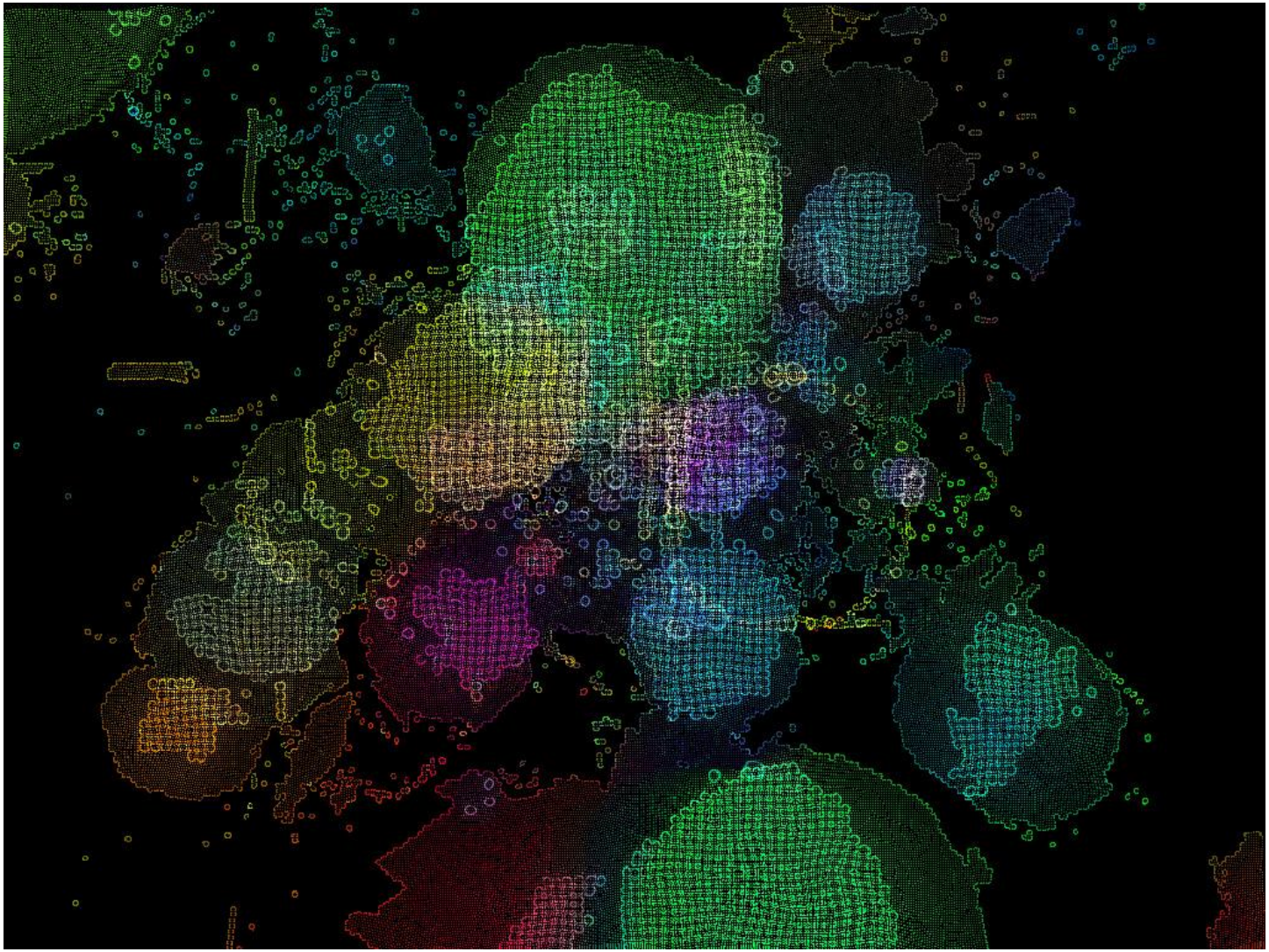

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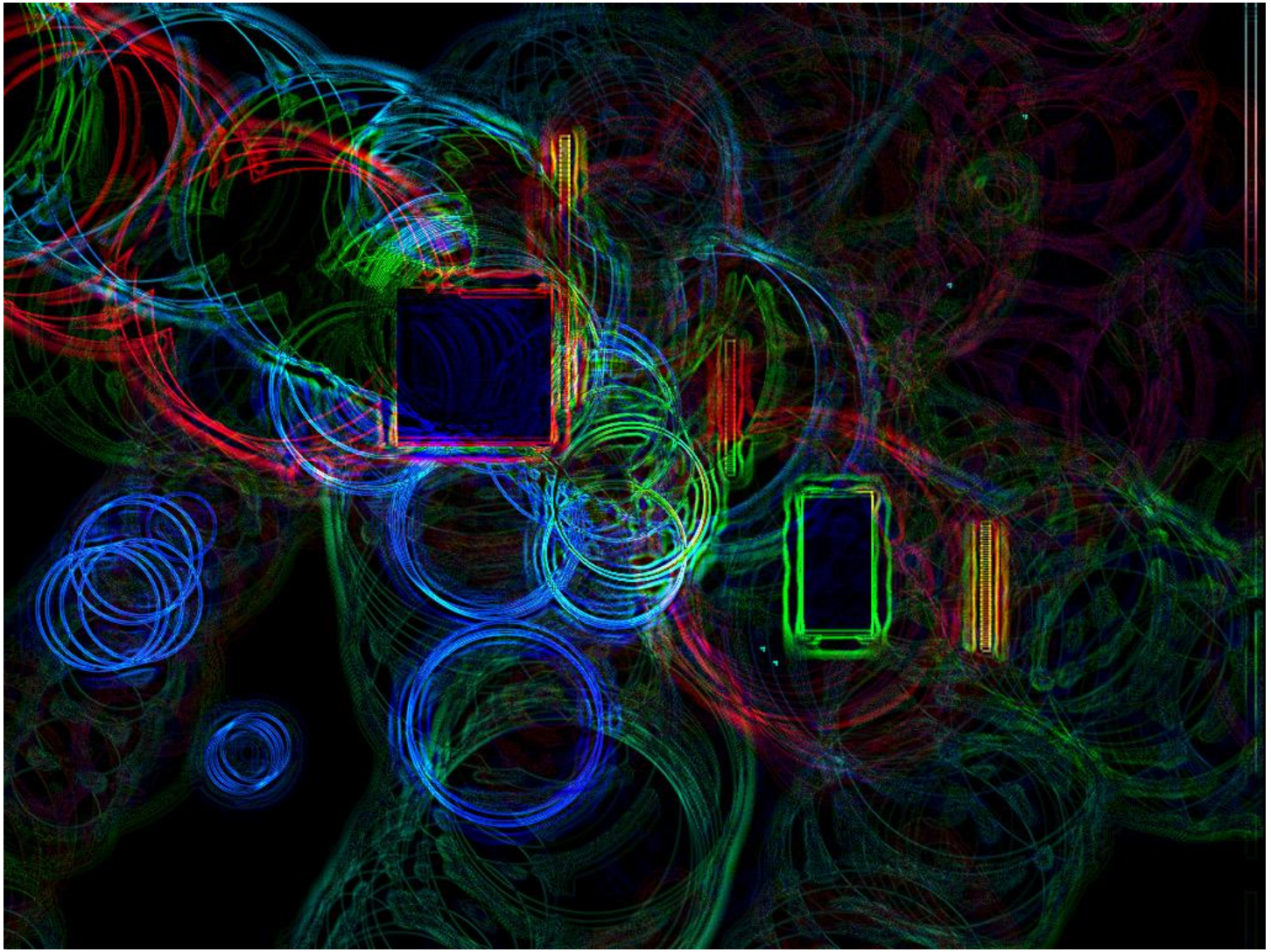

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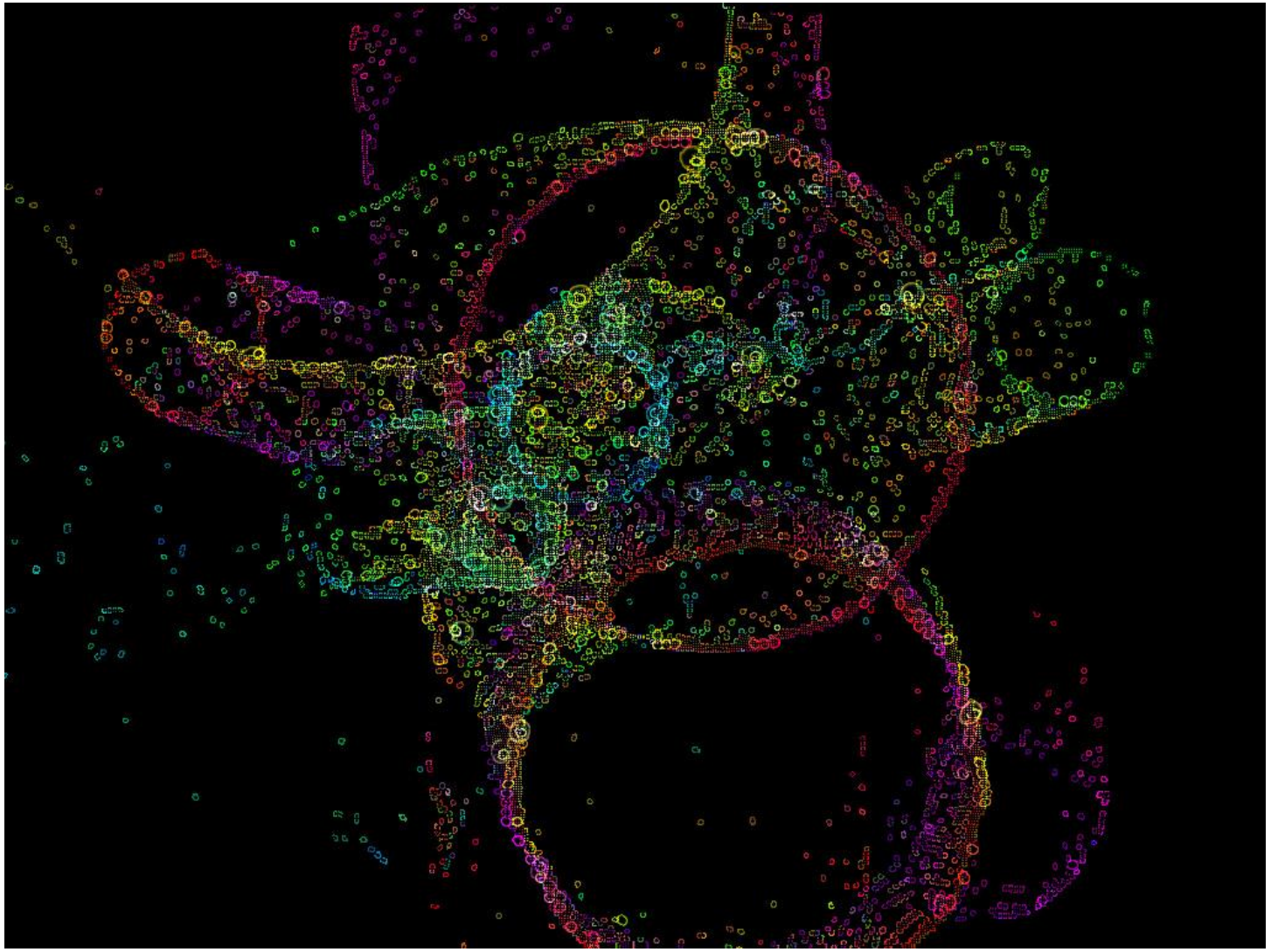


User Interface

- 4 buttons, 8 knobs, LCD, multitouch pad
- Knob style: endless rotation vs. absolute position ?
  - Hardware availability influenced the choice - absolute
- LCD used to 'label' the 8 knobs
- First iteration: many pages of parameters
- Second iteration: 2 pages of parameters (graphics & music)
- Third iteration: 1 page of parameters
- Expert mode allows access to all parameters

Code Pieces

- Languages
  - KeyKit
  - C/C++
  - Python
- Toolkits
  - Chipmunk (called from Python)
  - OpenCV (called from C/C++)
  - Cairo (called from Python)

Interface Pieces

- Standards
  - MIDI
  - Freeframe
  - OSC
- Hardware
  - Fingerworks iGesture multitouch pad (USB)
  - Doepfer USB64 MIDI control board (USB)
  - Pertelian LCD (USB)

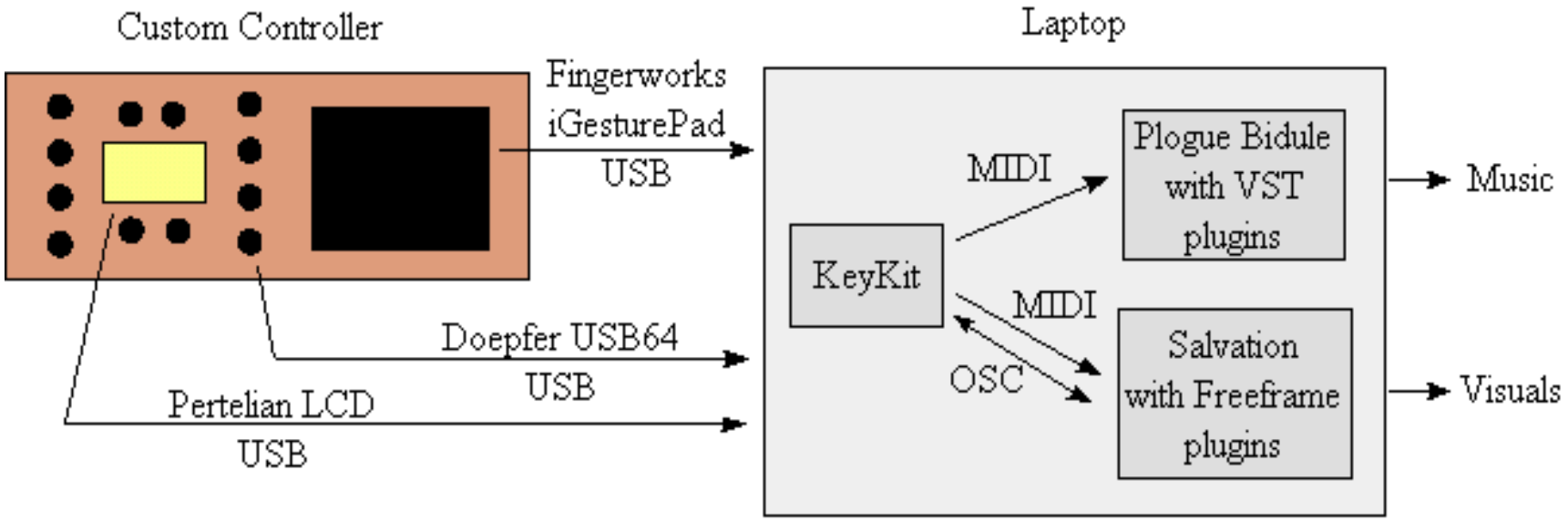
Application Pieces

- Applications
  - KeyKit
  - Salvation
  - Plogue Bidule
- Plugins
  - VST soft synths
  - Freeframe video processors
  - Planets plugin

My Pieces

- Decisions on what software and protocols to use
- KeyKit code for input processing and LCD control
- C and Python code in “Planets” Freeframe plugin
  - OpenCV for bitmap formatting/fading (from C)
  - OSC for 2-way communication with KeyKit (from C and Python)
  - Chipmunk for physics (from Python)
  - Cairo for 2d graphics (from Python)

What's connected to What



Event Routing

- Finger events are detected by Keykit, and either trigger sounds directly or get passed to Planets plugin via OSC, instantiating planets in Python code
- Python code simulates physics/gravity, moving planets
- When planets collide, a visual 'tracer' is generated (horizontal/vertical lines), and OSC is sent back to KeyKit to trigger a sound
- KeyKit sends MIDI to Plogue/VSTs to make sounds
- Knob and button movements are read by KeyKit as MIDI and processed by control logic in Keykit, occasionally sending OSC to Planets plugin to control its parameters
- KeyKit manipulates LCD display as knobs/buttons are used
- Music keyboard sends MIDI to KeyKit, for setting scales

Processing

- KeyKit has a MIDI looper, optionally enabled by a knob
- Generated MIDI is periodically transposed, in a cycle
- Planet motion is controlled by gravity and inertia in Python, invoked every frame (15 per second or so) from within a Freeframe plugin running inside Salvation
- Visual are generated by a serial chain of 3 Freeframe plugins:
  - Planets plugin does the initial drawing/movement, controlled by OSC from KeyKit
  - 2 other Freeframe plugins are controlled by MIDI
  - MIDI is sent from KeyKit to Salvation in order to select which 2 specific Freeframe plugins (from a set of several dozen) are used, and to control their parameters

Using Python from a Freeframe plugin

- “Planets” is the freeframe plugin, written in C/C++
- When it first initializes, the freeframe plugin:
  - Instantiates python
  - Recompiles/reloads nosuch.particles python module (so python code can be changed without restarting freeframe host)
  - Calls python to instantiate cairo surface and context
  - Retrieves a C-accessible surface and creates a C-accessible OpenCV image (IplImage)

Using Python from a Freeframe plugin

- On every video frame, the freeframe plugin:
  - Calls python to advance time, update planet positions and movement, and draw current planets onto the cairo surface
  - After returning to C code, the cairo surface is added to an accumulation buffer/image which is then progressively faded, using OpenCV routines.
- On every received OSC message, the freeframe plugin:
  - Sometimes adjusts parameters in the C code, but usually...
  - Forwards the OSC message intact to python to process it - changing parameter values, creating new planets, clearing, etc.

Other details

- Used PyBufferProcs to get access to PyCairo image surface
- Need to convert RGBA (from cairo) to RGB (for freeframe):
  - cvCvtColor(cairoimage1,accum1,CV_RGBA2RGB);

Python access to Chipmunk physics

```
import pymunk._chipmunk as cp
cp.cpInitChipmunk()
space = cp.cpSpaceNew()
moment = cp.cpMomentForCircle(mass, inr, outr, cpvzero())
body = cp.cpBodyNew(mass, moment)
cp.cpBodyResetForces(body)
cp.cpSpaceAddBody(space, body)
s = cp.cpCircleShapeNew(body, radius, cpvzero())
cp.cpSpaceAddShape(space, s)
cp.cpBodyApplyForce(body, force, cpvzero())
cp.cpSpaceStep(space, deltatime)
```

Python access to Cairo drawing

```
import cairo
s = cairo.ImageSurface(cairo.FORMAT_ARGB32,width,height)
c = cairo.Context(s)
c.set_source_rgba(r, g, b, a)
c.set_operator(cairo.OPERATOR_SOURCE)
c.set_line_width(width)
c.scale(sx, sy)
c.translate(tx, ty)
c.move_to(x,y)
c.curve_to(x1,y1, x2,y2, x3,y3)
c.rel_line_to(x,y)
c.fill()
c.stroke()
```

In Hindsight, the Good Things

- Python integration with low-level code works well, is robust, and has good syntax/error reporting
- Ability to change Python code without restarting the larger application is very nice
- Bitmap manipulation with multiple toolkits can work
- OSC is a nice simple API mechanism, and a good "side-channel" for controlling Freeframe plugins
- Local sockets for inter-app API invocation good for:
  - Flexibility in choice of languages and applications
  - Portability, Firewalling, Robustness
  - Separating device I/O from graphics/audio output

In Hindsight, the Bad Things

- Devices and drivers are often the weak link
  - Things that work in isolation may not work simultaneously
  - The more devices you have, the more problems you have
  - Always try to have a quick way of resetting/restoring things that is controllable from the primary interface
- Absolute knob style is a pain
- Version control is a pain with so many pieces
- Giving it to other people is difficult
- OS dependencies

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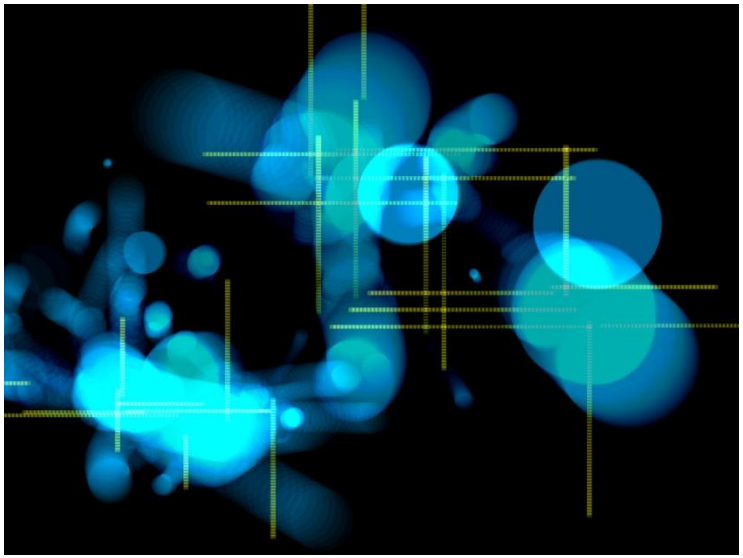

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