

KeyKit

20 years of toys and tools for MIDI

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Outline

- History
- Language and GUI
- Algorithmic, Interactive, and Realtime Tools
- Hardware Interfacing
- Recent projects

What is it?

- Textual programming language – procedural, interpreted, multi-tasking, graphics, object-oriented
- Specialized for MIDI algorithmic and realtime manipulation, first-class “phrase” data type, realtime scheduling
- Multi-window graphical user interface, pull-off menus and buttons, tools include multi-track editor, drum pattern editor
- Entire user interface and all tools written in the language and provided as source code in library, easily customized and extended

Reason for Being

- Hacking - fun, programming, normal music composition, algorithmic music
- Learning - OS's, device drivers, graphics, user interface design, OO
- Personal and programmer-centric, not commercial, although it is usable enough for non-programmers

Development History

- 1.0 - BASIC-like
- 2.0 - realtime
- 3.0 - grammer, rewrite, fast enough to avoid built-ins
- 4.0 - graphics
- 5.0 - first multi-window attempts, multi-tasking, fifos, tools using tasks/fifos
- 6.0 - object-oriented, multi-window interface completely rewritten, pull-off menus/buttons
- 7.0 – support for multiple MIDI ports

Development machines

- Atari ST, PC (286), UNIX (386, X11), Windows NT, Win95/98/XP
- Ported at various times to: Atari ST, DOS, UNIX PC, Mac, Amiga, SVR3, SVR4, SunOS, NeXT, X Windows, SGI, Amdahl, VAX, 5620, Plan 9, Windows 3.1/NT/95/98/XP

MIDI Phrase is a first-class data type

- Time-ordered list of MIDI “notes” - can be system-exclusives, isolated note-on, isolated note-off, or full note with duration

- Constant value syntax

```
ph = 'c e g'           # ph is a c major triad
```

```
ph = 'dc2,e,f'        # ph is an arpeggio, channel 2
```

- Structure-like manipulation of attributes :

```
ph.dur = 1b           # all note durations = 1 beat
```

```
ph.pitch += 12        # transposed up an octave
```

Phrase/Note Attributes

- pitch (0-127)
- vol(0-127)
- chan (1-16)
- dur (in clicks)
- time (in clicks, relative to beginning of phrase)
- type (NOTE, NOTEON, NOTEOFF, MIDIBYTES, PROGRAM, PRESSURE, etc.)
- length (of phrase, independent of notes in it)
- attrib (string, arbitrary meaning)
- flags (integer, arbitrary meaning, bit 1 == picked)

Phrase Operations

- Serial concatenation

$$\mathbf{ph} = \mathbf{ph1} + \mathbf{ph2}$$

- Parallel merging

$$\mathbf{ph} = \mathbf{ph1} \mid \mathbf{ph2}$$

- Removing notes

$$\mathbf{ph} = \mathbf{ph1} - \mathbf{ph2}$$

- Matching notes

$$\mathbf{ph} = \mathbf{ph1} \& \mathbf{ph2}$$

- Nth note

$$\mathbf{ph} = \mathbf{ph1} \% n$$

Phrase Operations - the “select”

```
ph = ph1 { ?? .pitch > 60 }
```

```
ph = ph1 { ?? .dur > 1b }
```

```
ph = ph1 { isonbeat(??, 4b) }
```

```
ph = ph1 { ?? .number < 4 }
```

```
ph = ph1 { rand(3) == 0 }
```

```
ph = ph1 { isinscale(??, scale) }
```

```
ph = ph - ph { ?? .type == MIDIBYTES }
```

Language Features

- Inspired by awk (a Unix scripting language)
- Variables need not be declared
- Semicolons not required
- `#define`, `#include`
- The usual control structures and expressions (although no `switch`)

Phrase Operations - Looping

```
# randomize volume of each note and  
# construct a new phrase with the result  
r = ``  
for ( nt in ph ) {  
    nt.vol += rand(10)  
    r = r | nt          # or      r |= nt  
}
```

```
# randomize volume of each note, in-place  
for ( n=0; n<sizeof(ph); n++ )  
    ph%n.vol += rand(10)
```

Function values

```
function major(k) {  
    return(k | transpose(k,4) | transpose(k,7)) ;  
}
```

```
function minor(k) {  
    return(k | transpose(k,3) | transpose(k,7)) ;  
}
```

```
function randchordtype() {  
    if ( rand(2) == 0 )  
        return(major)  
    else  
        return(minor)  
}
```

```
f = randchordtype()    # value of f is a function  
f('c')  
randchordtype() ('c')
```

Other Language Features

- Variable arguments - ... , nargs(), argv(), varg()
- Fifos and locking
- Objects
- Graphics - primitive elements are:
lines, rectangles, text, windows,
phrase windows, menus
- Machine-dependent hook – mdep() – used to
add/expose non-portable features
- TCP/IP hooks available for Windows and Linux,
network interaction

Variable Arguments

```
function calleither(f1,f2,...) {  
    if (rand(2) == 0) {  
        f1(...)  
    } else {  
        f2(...)  
    }  
}
```

```
P = calleither(flip,reverse,p)
```

```
P = calleither(scadjust,scafilt,p,scale1)
```

Tasks and I/O

- All tasks are time-shared evenly, interleaved at the interpreted instruction level
- Scheduled MIDI output events are tasks as well, but performance can't be degraded by other tasks
- MIDI input is always being recorded, available in a global variable for easy and immediate processing
- MIDI, mouse, and console input events can be read from special fifos
- Reading a fifo (with no data waiting) blocks a task
- `lock()` and `unlock()` used for exclusion and synchronization

KeyKit - the GUI

- Completely implemented with Keykit code, even pull-off menus, dragging of windows, window-manager-like operations, etc.
- Each tool is independent, with consistent methods for resizing and inter-tool communication
- Consistent saving/restoring mechanism of individual tools is highly leveraged, used for:
 - Copying between like tools
 - Copy/paste of entire tools
 - Moving tools between “pages”
 - Manipulating of tools within tools
 - Broadcasting of a tool and its contents across a network

Variety of Tools

- Why so many?
 - **Improvisational interactive programming**
- Ball Maze, Bang, Blocks, Boomix, Bounce, Chords, Console, Controller, Echo, Espresso, FourPlay, Fractal, Gene Pool, Ginsu, Grab Bag, Grind, Group, Kboom, Konnect, Loopy, Markov Maker, Monitor, Mouse Matrix, Mousey, Parameters, Party, Peer, Picture This, Prog Change, Quix, Remapper, Riff, RiffRaff, Roller, Sectionalize, Techno, Tempo, Video Decay, Volume, Woolls Bargaen, and others

File View Edit Norm Aud Aud

Merged Name: New #

Trk 1 S M X None

Gra M P P M 1 A W Lo

Grab Bag

Roller Derby R Loo Mor Ch

Lo Hi Swee Sp

#0 #0 #0 #0

U D S L S L S L U D S L

On More

On

tim	trav	vol	nti
1.0	0	90	1

Roller Derby

Techn 16 More Loop

On More

Techno

Boomix! On Resync More

0 1 2 3 4 5

Boomix

Mouse Matr 1 note

Mouse Matrix

Bounce On

Spe O M L

O M L O M L

Bounce

key> Turning Merge off...
Turning Merge back on...

TOOL VARIETY

Summary of Unique Strengths

- Phrase (as opposed to note) manipulation supported directly by the language syntax
- Interpreted language makes iterative development a breeze - immediate feedback
- Robust - syntax and execution errors do not bring the system (or even other tasks) down
- Associative arrays - simple but powerful
- Finely-grained multi-tasking gives graceful sharing of CPU, no degradation in realtime scheduling

Summary of Unique Strengths (continued)

- Textual language allows concise expression of:
 - Reusable parameterized utility functions
 - Time-ordered layout of composition
 - Data-driven algorithms
 - Independent algorithms running in parallel
- GUI framework encourages “tool-oriented” approach
- Same language used to implement GUI and all tools, no need to escape to (or learn) C

Availability and Resources

- Freely available, with complete source code
- Win95/98/NT/XP and Linux executables
- Mac port exists, but needs lots of polishing
- Download site:
 - **`http://nosuch.com/keykit`**
- Documentation
 - Tutorial, tools reference, language reference, hacking guide
- Mailing list

What are other people doing with it?

- Mailing list has 3000 people, not much visible activity, but evidence of lots of experimentation
- Burton Beerman – composition with BodySynth
- Tim Perkis’ performance instrument
- David Wooll’s “Bargen” tools

Version 1

Structured Melody Maker

4/4	Oct	Bpm	1	Volume	Gen	Adj.To
Major	3	12		Bea 100		C
Melody	Key	12	1	Off 60	MoveTo	
Bar	8	C	12	1		C

Tempo=500000

Version N

Structured Melody Maker - Uersion 2.1a

6/16	Bea	65	Imp	File	New	C		
Oct	3	Off	60	Mak	Sna	Modulate	T/U	Off
Bar	4	Sec	12			Transpos	Bpm	100
Key	C	Major				R3 Re-Ha	Uol	100
H3 Harmd								
			1 >	< 4				
			Pla	Uie	Pic			
			View	Edit	Normal	Aud Sw	Aud Pl	
Merged			Name: New Autogen	#	Tr			

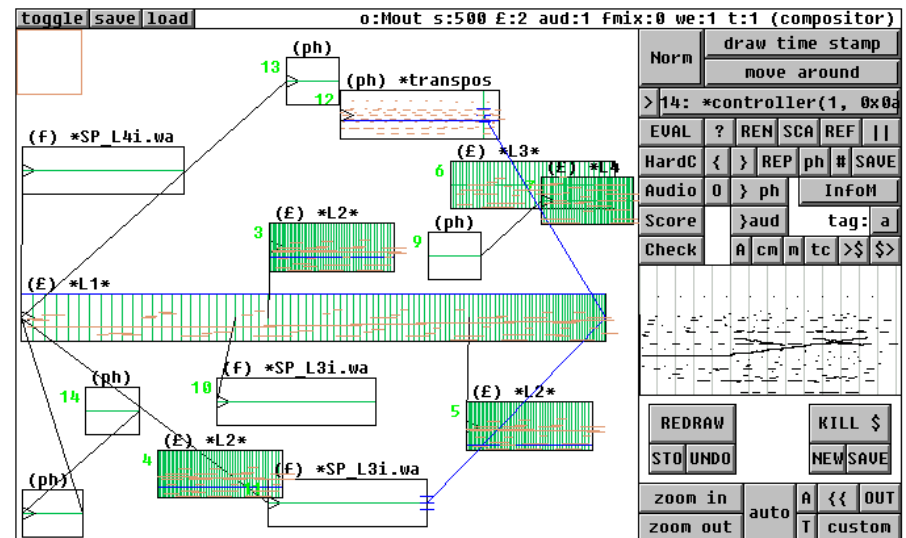
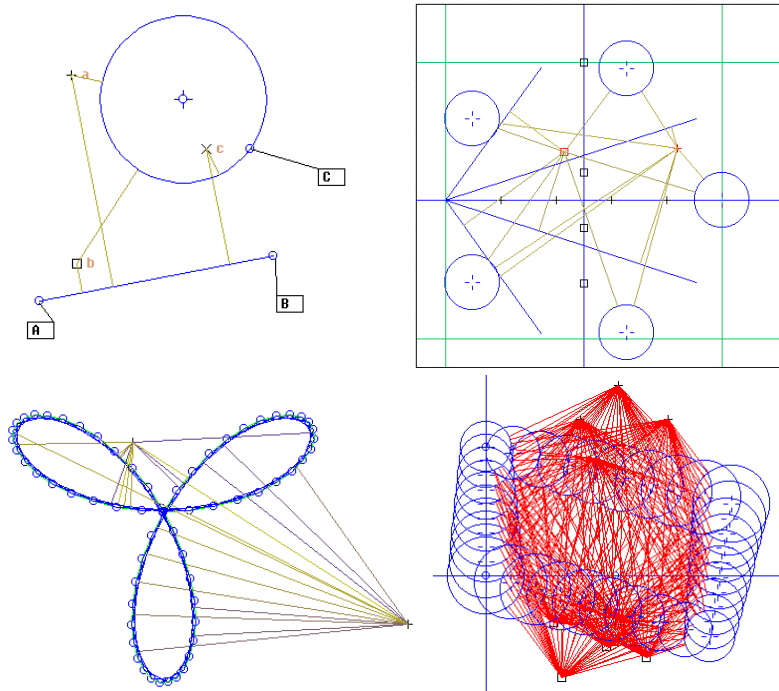
Re-used Group tool

Geomaestro – WOW!

- By Stephane Rollandin, well documented:

<http://www.zogotounga.net/GM/paper1.html>

- Chosen (along with KeyKit) in recent Art.Bit collection in Japan: <http://www.art-bit.jp>



What is Tim doing with it?

- Algorithmic - Espresso
- Interactive - Gene Pool, Picture This
- Realtime – Typo, Hoops
- Network - Konnect
- Hardware interfaces
 - Playstation controllers (dance pads, wireless joysticks)
 - QWERTY
 - Relays
 - Webcam
 - iGesture

Algorithmic Tools - Espresso

- L-systems fractal generation
- Driven from file of expression transformations
- Starting expression is “X”
- After 10-20 generations, expression is huge
- Substituting note or small phrase for X produces wide variety of results
- Used interactively for Woodstockhausen 2000
- Basis of several Tune Toys on nosuch.com
- Algorithmic Shorts 2001 – “23 Shots of Espresso”

Espresso – default transformations

```
# This is a set of transformations for espresso
A = A+A
A = A|A
A = transpose(A,4)
A = transpose(A,-5)
A = transpose(A,-7)
A = A+transpose(A,12)
A = A+transpose(A,7)
A = A+transpose(A,4)+transpose(A,7)
A = echo(A,4,6)
A = step(A,12)
A = arpeggio(A)
A = shuffle(A)
```

Expresso – GUI interface

The screenshot shows the Expresso GUI interface. The top panel contains several controls: a title bar 'Expresso default', a 'More' button, a 'Ran' field with the value '1050818', a 'v' field with 'No d', a 'g' field with '15', an 'o' field with '0', a 'c' field with '1', a '#' field with '6', and buttons for 'All', 'Gen', and 'Grab'. Below the top panel is a large window displaying a complex, noisy waveform or signal plot.

Annotations with red arrows point to specific elements:

- Generates new result**: Points to the 'Gen' button.
- Phrase to use for value of X**: Points to the 'v' field containing 'No d'.
- # of generations**: Points to the 'g' field containing '15'.
- # of tracks to generate**: Points to the '#' field containing '6'.

8 Espresso ★ tools used interactively in “21st Century Caffeine-based Life Form” at Woodstockhausen 2000

The screenshot displays the KeyKit application window titled "21st Century Caffeine-Based Life Form by Tim Thompson". The interface is a complex grid of interactive elements:

- Timer:** A control with a numeric display showing "10" and "Sta".
- Espresso Tools:** Multiple instances of the Espresso tool, each with a header "Espresso" and a control panel. The panels include fields for "Expr default", "r AI", "Gen", and "Grab". Below these are data fields: "More Ra 1107", "v No", "g 8", "o -", "c 5", "# 1". Each tool also features a small graph or waveform display.
- On/Off:** A central control with "On" and "Off" buttons.
- Volume Control:** A section titled "Volume Contro" with a "More" button and a bar graph showing values "1 2 3 4 5 6 7 8 9 1 1 1 1 1 1".
- Programs:** A section with "More" and "Rand" buttons, and a "Ch Program" label above a series of horizontal bars.
- Terminal:** A terminal window at the bottom left showing the prompt "key>" and the input "key> _".

Red stars are placed over several Espresso tool windows, highlighting specific instances used during the performance.

Audio examples using Espresso

21st Century Caffeine-based Life Form (Woodstockhausen 2000)

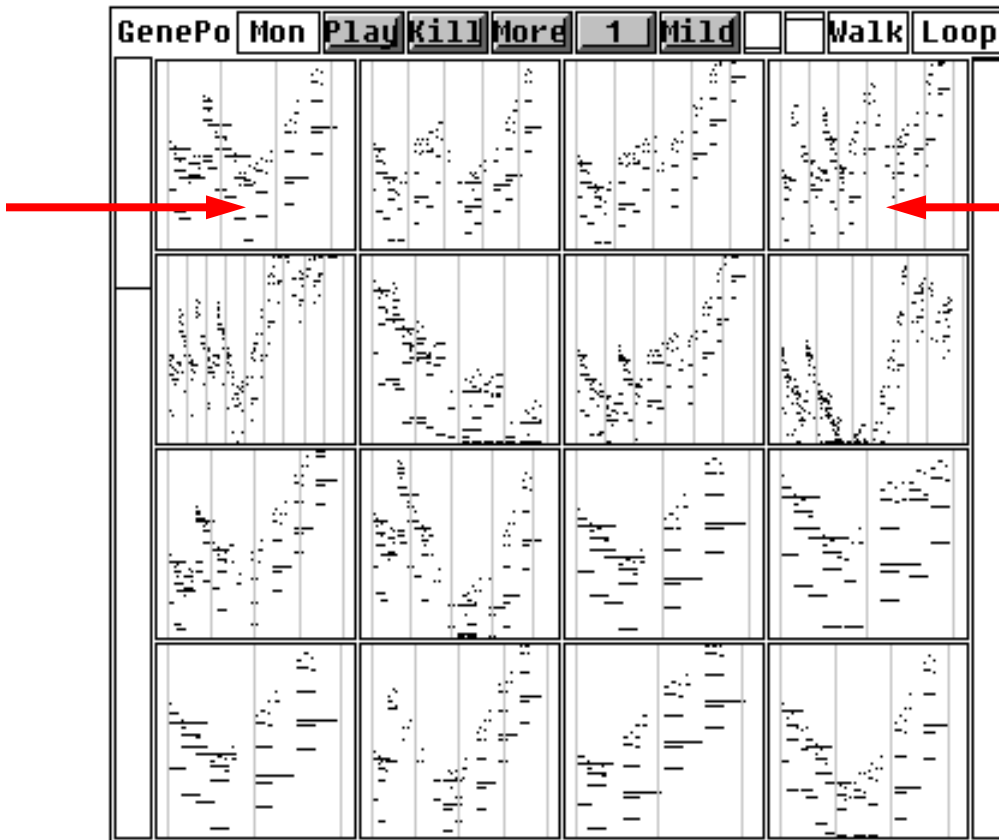
23 Shots of Espresso (Algorithmic Shorts 2001)

Interactive Tool - Gene Pool

- Uses small instruction set of musical opcodes
- Each opcode does one thing:
 - Adjust pitch (or time, velocity, duration) of current note
 - Set pitch (or time, velocity, duration) of current note
 - Trigger note (i.e. add current note to the generated result)
- Any phrase can be disassembled into a sequence of musical opcodes that generates it
- Mating of these sequences produces new generations
 - Take half of one, half of the other
 - Shuffle them
 - Etc.

Gene Pool – GUI

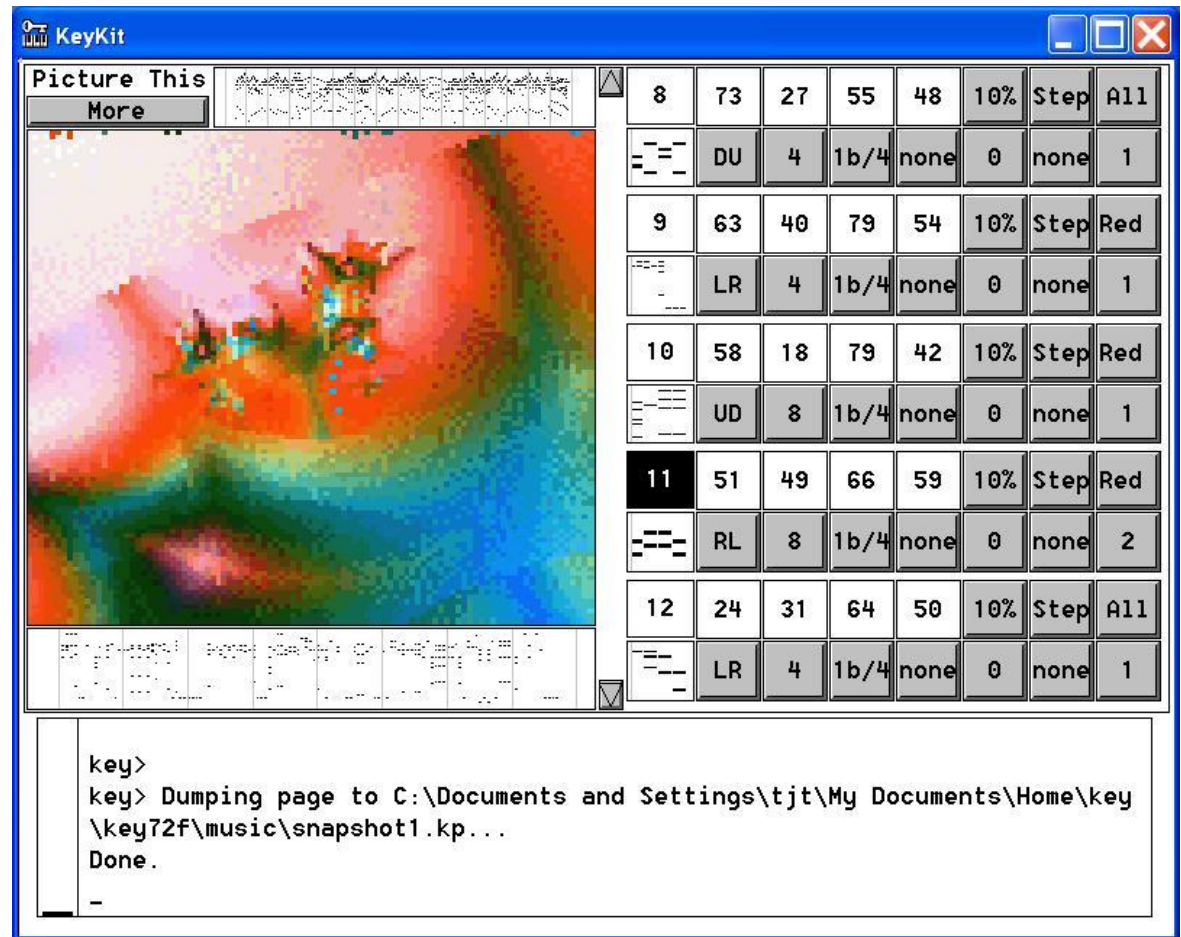
Left-click
plays



Right-click
kills and fills
by mating
survivors

Interactive Tool - Picture This

- Use RGB values of an image in various ways



The screenshot shows the KeyKit application window. The main area displays a color image of a bird. To the right of the image is a table with 8 columns and 8 rows of data. The table contains keycodes and their corresponding values. Below the table is a command prompt window showing the output of a 'Dumping page' command.

8	73	27	55	48	10%	Step	All
	DU	4	1b/4	none	0	none	1
9	63	40	79	54	10%	Step	Red
	LR	4	1b/4	none	0	none	1
10	58	18	79	42	10%	Step	Red
	UD	8	1b/4	none	0	none	1
11	51	49	66	59	10%	Step	Red
	RL	8	1b/4	none	0	none	2
12	24	31	64	50	10%	Step	All
	LR	4	1b/4	none	0	none	1

```
key>  
key> Dumping page to C:\Documents and Settings\tjt\My Documents\Home\key  
\key72f\music\snapshot1.kp...  
Done.  
-
```

Realtime Tool - Typo

- QWERTY keyboard used as controller
- Based on ability to receive QWERTY up/down events (Windows-specific)
- Most keys used to play notes; holding down control key used to access other functions
- Holding down shift key causes notes to be recorded and looped
- Number keys 0-9 control “sections” – each section retains sound choices and looped notes
- “Oops, I Made a Typo” - Woodstockhausen 2001



Oops, I made a typo

(Woodstockhausen 2001)



Realtime Tool - Hoops

- Collaboration with Herb Heinz
- Extension and simplification of Typo
- No quantized loop length, tempo tapped after first loop
- All control through MIDI (no QWERTY)
- Control buttons: REC, UNDO, CHAN, TAP, QUANT, TRANS, NUDGE, MUTE, BEAT, COPY
- Some controls are chorded with notes to provide values:
 - CHAN+'D' sets channel to 3
 - TRANS+'E' transposes current channel by 4
- Holding down 'C' applies it to all channels
 - TRANS+'C'+ 'E' transposes all channels by 4

Network Tool - Konnect

- Uses Linux and Windows-specific hooks
- Broadcast of MIDI data in realtime
- Simple text-chat
- Two-way resynchronization with 4-beat delay
 - Each side continuously transmits and receives
 - Received data is resynchronized to local timing
 - What you hear during a given 4 beats is what the other side played in response to the 4 beats you just finished several beats ago.
- Linux server runs KeyKit process that serves as proxy/broadcaster, >2 clients can connect and jam simultaneously

Playstation Controller Interfacing

- PS2-to-USB interfaces, not all created equal
- EMS USB 2-port interface works well (available at www.levelsix.com or www.gocybershop.net)
- Windows driver makes dance pad look like buttons on a joystick, works with standard multimedia API
- Able to connect 4 interfaces (8 pads) simultaneously
- Pads and interfaces have been surprisingly reliable



KeyKit hooks for Playstation devices

- It's a generic joystick interface – anything with a Windows driver that looks like a joystick will work
- Windows events (and/or polling) generate keykit events
- Looks like a fifo in the KeyKit language, just like mouse/console/midi/network inputs
- Good responsiveness
- Order of devices is non-deterministic, need to establish order interactively, if order is important

Wireless joysticks

- Anything that looks like a joystick becomes a music controller
- Logitech wireless joysticks for the Playstation work well (with EMS USB2 interface), and have natural layout of buttons for performance
- 10 buttons + 4-button joypad + 4 axis of analog joystick control
- Both button-down and button-up events can be used

Video input

- Windows-specific feature, uses DirectShow API
- Grabs samples of video, provides averaged low-res (adjustable) grid of RGB values

Dance Pads



Dance Pads at Burning Man 2002



Happy Feet – a composition for Dance Pads

- Performance at Woodstockhausen 2002
- Bach's "Jesu, Joy of Man's Desiring" provides notes
- Music broken into snippets by time or attacks
- Snippets assigned across all 4 dance pads, in sets
- Advancing through sets is controlled by select button
- 4 sections in performance

Dance Pad UI

- 8 main buttons play notes or snippets
- Select and Start buttons, followed by a main button, perform control functions
- Pressing Select or Start multiple times (2 or 4) is used to perform less-common functions
- Each of 4 pads is independent and usually identical, some functions affect one pad, some affect all pads
- People try the Select and Start buttons without knowing what they do – need to “hide” functions more

Dance Pad Controls

SELECT

NEXT RHYTHM	MORE NOTES	PATCH CHANGE
ARPEGGIO		PATCH RANDOM
ADVANCE	LESS NOTES	PATCH TYPE CHANGE

START

CLEAR LOOP	OCTAVE UP	RECORD ON/OFF
SHORTER DURATION		LONGER DURATION
SOFTER	OCTAVE DOWN	LOUDER

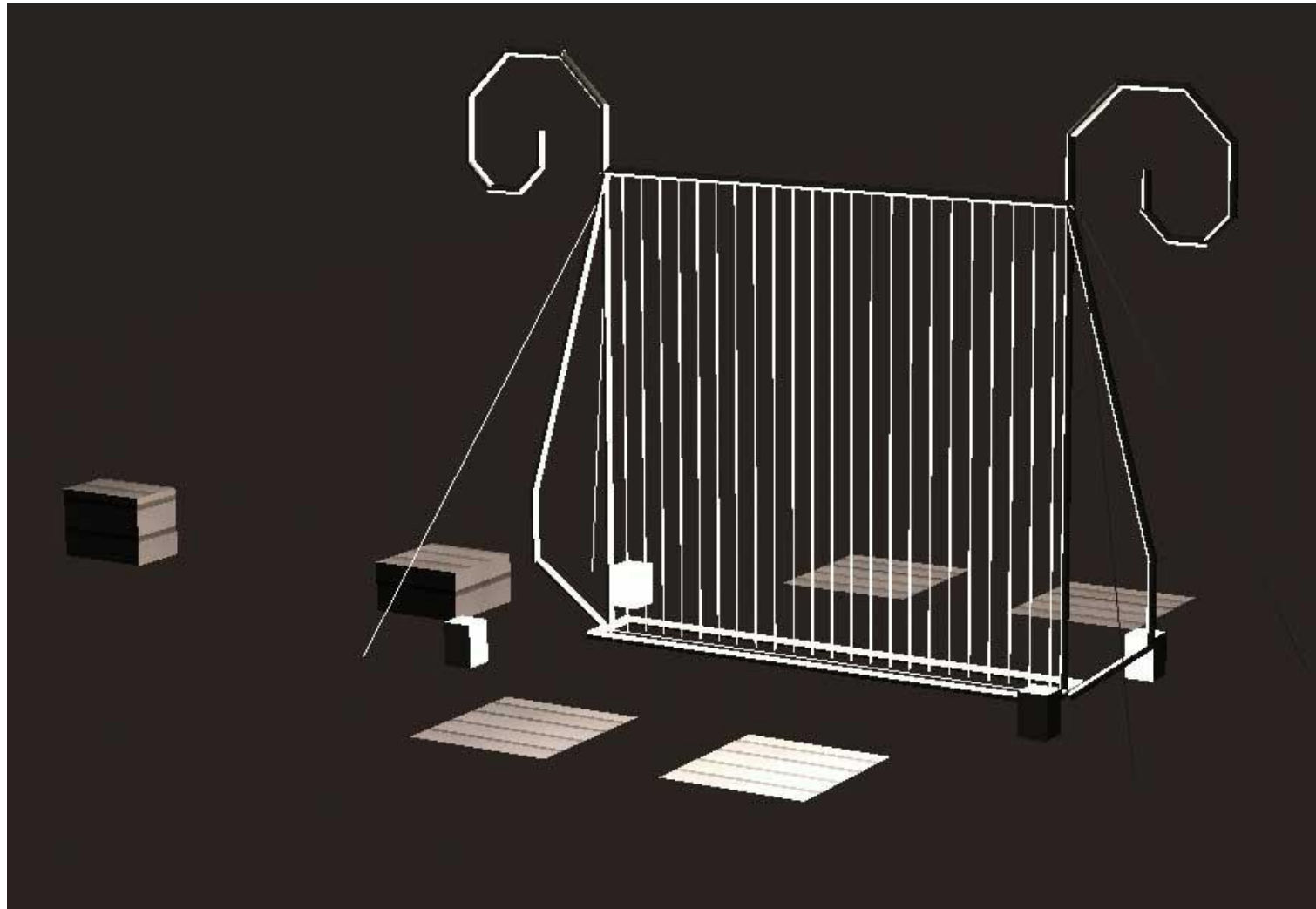
SELECT 2

RHYTHM ON/OFF		PATCH RESET
DRUMS ON/OFF		

START 2

RESET ALL	FASTER	FADE ON/OFF
SHORTER LOOP		LONGER LOOP
	SLOWER	

Dance Pads at Burning Man 2003



Dance Pads at Burning Man 2003



Click on image
to see video
of lyre in action →



Dance Pads at Burning Man 2003



Dance Pads at Burning Man 2003



Dance Pads at Burning Man 2003



Dance Pads at Burning Man 2003



Wireless QWERTY + Dance Pad

- NoSuch Music at 26Mix, San Francisco dorkbot, and San Jose Works Gallery

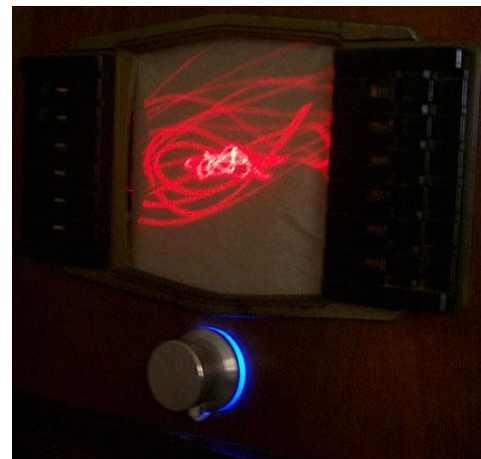


← dork @
dorkbot



Radio Free Quasar

- Burning Man 2004
- Antique radio with computer inside
- Python-based VST host
- Randomized VST parameters
- Controlled by Big Silver Knob (Griffin Technologies)
- Audio-controlled laser display



iGesture pad

- www.fingerworks.com
- Inexpensive multi-touch pad
- Excellent responsiveness
- KeyKit interface to event stream
- Event data: x, y, proximity, eccentricity, orientation, contacts, device, finger, hand, xvelocity, yvelocity
- Multiple pads can be used simultaneously

iGesture Pad



Visual Music experiments

- Python used for OpenGL support
- KeyKit is interface to input devices (MIDI, iGesture)
- Messages sent over TCP/IP to Python process
- 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
- Used in dud (improvised art ensemble) - www.dudland.com

Etcetera

- Simple OSC (Open Sound Control) support

Availability and Resources

- Freely available, with complete source code
- Win95/98/NT/XP and Linux executables
- Mac port exists, but needs polishing
- Documentation
 - Tutorial, tools reference, language reference, hacking guide
- Mailing list
- Download site: <http://nosuch.com/keykit>
- Questions: tjt@nosuch.com