KeyKit

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Outline

• History
• Language and GUI
• Algorithmic Tools
• Interactive Tools
• Realtime Tools
• Hardware Interfacing
• Combinations thereof
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 current version is complete enough for non-programmers
Development History

• 1.0 - BASIC-like
• 2.0 - realtime
• 3.0 - grammar, 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
Language Features

- Inspired by awk
- Variables need not be declared
- Semicolons not required
- `#define`, `#include`
- The usual control structures and expressions (although no `switch`)
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
  
  ```python
  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:
  
  ```python
  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
  \[ ph = ph1 + ph2 \]
- Parallel merging
  \[ ph = ph1 \mid ph2 \]
- Removing notes
  \[ ph = ph1 - ph2 \]
- Matching notes
  \[ ph = ph1 \& ph2 \]
- Nth note
  \[ ph = ph1 \% n \]
Phrase Operations - the “select”

\[
\begin{align*}
    ph &= ph1 \{ \ ??\.pitch > 60 \} \\
    ph &= ph1 \{ \ ??\.dur > 1b \} \\
    ph &= ph1 \{ \ isonbeat(??,4b) \} \\
    ph &= ph1 \{ \ ??\.number < 4 \} \\
    ph &= ph1 \{ \ rand(3)==0 \} \\
    ph &= ph1 \{ \ isinscale(??,scale) \} \\
    ph &= ph - ph \{ \ ??\.type == \text{MIDIBYTES} \}
\end{align*}
\]
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

```javascript
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

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

P = calleither(flip,reverse,p)

P = calleither(scadjust,scafilt,p,scalen1)
```
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, Expresso, 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 Bargen, and others
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, little visible activity, but evidence of lots of experimentation
- Burton Beerman – composition with BodySynth
- David Wooll’s “Bargen” tools
Geomaestro – WOW!

- By Stephane Rollandin, well documented:  

- Chosen (along with KeyKit) in recent Art.Bit collection in Japan:  
What is Tim doing with it?

- Algorithmic - Expresso
- Interactive - Gene Pool, Picture This
- Realtime – Typo
- Network - Konnect
- Hardware Controllers
  - Playstation (dance pads, wireless joysticks)
  - Video
Algorithmic Tools - Expresso

- 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 performance
- Basis of several Tune Toys on nosuch.com
Expresso – default transformations

```plaintext
# This is a set of transformations for expresso
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

Generates new result

Phrase to use for value of X

# of generations

# of tracks to generate

# of generations

# of tracks to generate
8 instances (★) of Expresso tool used interactively in “21st Century Caffeine-based Life Form” at Woodstockhausen 2000
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
Realtime Tool - Typo

• Typing keyboard used as musical controller
• Based on ability to receive console up/down events (Windows-specific addition to keykit)
• 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
• Used for Woodstockhausen 2001 performance
Network Tool - Konnect

- Uses Linux and Windows-specific hooks
- Broadcast of MIDI data in realtime
- Simple text-chat
- Two-way synchronization 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](http://www.levelsix.com) or [www.gocybershop.net](http://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 joystick/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
Dance Pads
Dance Pads at Burning Man 2002
Dance Pads at Burning Man 2003
Happy Feet – a composition for the 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

<table>
<thead>
<tr>
<th>NEXT RHYTHM</th>
<th>MORE NOTES</th>
<th>PATCH CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARPEGGIO</td>
<td>LESS NOTES</td>
<td>PATCH TYPE CHANGE</td>
</tr>
<tr>
<td>ADVANCE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Start

<table>
<thead>
<tr>
<th>CLEAR LOOP</th>
<th>OCTAVE UP</th>
<th>RECORD ON/OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHORTER DURATION</td>
<td>LONGER DURATION</td>
<td></td>
</tr>
<tr>
<td>SOFTER</td>
<td>OCTAVE DOWN</td>
<td>LOUDER</td>
</tr>
</tbody>
</table>

## Select 2

<table>
<thead>
<tr>
<th>RHYTHM ON/OFF</th>
<th>PATCH RESET</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRUMS ON/OFF</td>
<td></td>
</tr>
</tbody>
</table>

## Start 2

<table>
<thead>
<tr>
<th>RESET ALL</th>
<th>FASTER</th>
<th>FADE ON/OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHORTER LOOP</td>
<td>LONGER LOOP</td>
<td></td>
</tr>
<tr>
<td>SLOWER</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Video input

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

• Ball Maze
  – Mouse
  – Wireless Joystick
  – Video
Availability and Resources

• Freely available, with complete source code
• Win95/98/NT/XP and Linux executables
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