

Command Line Algorithmic Music System (CLAMS)

M. Edward (Ed) Borasky

2023-03-25

Me and Forth

Me - retired scientific applications / operating systems programmer

- ▶ I got paid to write
 - ▶ Assembly - lots of assembly!
 - ▶ Fortran - only when management required me to
 - ▶ Awk/sed/grep/*nix shell
 - ▶ Perl
 - ▶ R

I learned for hobby projects

- ▶ Lisp
- ▶ Forth
- ▶ Ruby

I never learned

- ▶ COBOL
- ▶ APL
- ▶ SNOBOL4
- ▶ Smalltalk
- ▶ Algol/Pascal/C/C++/Java/C#/Objective C/D/Rust/Go
- ▶ PHP
- ▶ Python
- ▶ JavaScript

Forth

- ▶ 1980s
 - ▶ learned Forth via HESForth on Commodore 64
- ▶ mid-late 1990s
 - ▶ primary Forth engine was HP100LX Palmtop PC
 - ▶ 16-bit 80186
 - ▶ wrote some articles for FORTH Dimensions
 - ▶ wrote some trading system software
 - ▶ used mostly hforth and Tom Almy's Forth compiler

Why I stopped writing Forth

- ▶ by 1999 I had faster machines that ran my hobby code in Perl
- ▶ I wasn't using Forth at work
- ▶ I was learning Linux and R at work
- ▶ Too much mental context switching kills productivity!

(Two sunspot cycles pass ...)

He's baaack! And he brought ... CLAMS!

CLAMS goal

- ▶ algorithmic music composition and performance ...
- ▶ live ...
- ▶ in real time ...
- ▶ on a Raspberry Pi Pico!

About the RP2040 processor

- ▶ Dual-core Arm Cortex-M0+ processor, flexible clock running up to 133 MHz
- ▶ 264kB on-chip SRAM
- ▶ $2 \times$ UART, $2 \times$ SPI controllers, $2 \times$ I2C controllers, $16 \times$ PWM channels
- ▶ $1 \times$ USB 1.1 controller and PHY, with host and device support
- ▶ $8 \times$ Programmable I/O (PIO) state machines for custom peripheral support

About the Raspberry Pi Pico board

- ▶ 2 MB flash
- ▶ four versions
 - ▶ Raspberry Pi Pico: \$4US, surface mount
 - ▶ Raspberry Pi Pico H: \$5US, male headers and a serial wire debug (SWD) connector
 - ▶ Raspberry Pi Pico W: \$6US, surface mount, 2.4 GHz wireless
 - ▶ Raspberry Pi Pico WH: \$9US, male headers, 2.4 GHz wireless
- ▶ the wireless ones tend to be hard to get ... usually bundled in starter kits

Software inspirations - HMSL

- ▶ Hierarchical Music Specification Language (HMSL)
- ▶ long history and experience with experimental composers
- ▶ currently being actively enhanced!
 - ▶ <https://github.com/philburk/hmsl.git>
- ▶ based on pforth
 - ▶ <https://github.com/philburk/pforth.git>

Software inspirations - FORMULA

- ▶ FORMULA - FORth MUsic LAnguage
- ▶ designed for improvisation in real time
- ▶ contained a real-time operating system
- ▶ ran on inexpensive hardware
- ▶ David P. Anderson and Kuivila (1989), D. P. Anderson and Kiuivila (1991)
- ▶ Python successor: Numula
<https://github.com/davidpanderson/Numula/wiki>

Software inspirations - Live coding

- ▶ *Live Coding: A User's Manual* (Blackwell et al. 2022)
- ▶ The TOPLAP Manifesto
 - ▶ “Show Us Your Screens”
 - ▶ <https://toplap.org/wiki/ManifestoDraft>
- ▶ GitHub Awesome Live Coding
 - ▶ <https://github.com/toplap/awesome-livecoding>

CLAMS architecture

- ▶ a domain-specific language implemented in Forth
- ▶ conceptually, ChuckK (<https://chuck.cs.princeton.edu>), (Salazar et al. 2014) semantics with Forth syntax
 - ▶ low-level words: digital synthesis and microcontroller audio
 - ▶ mid-level words: construct signal flow graph
 - ▶ high-level words: algorithmic composition and live performance

Forth base: zeptoforth

Highly optimized!

- ▶ subroutine-threaded
- ▶ allows inline expansion of words
- ▶ many primitives in assembly

Close to the metal

- ▶ words for nearly all the RP2040 hardware
- ▶ has an RP2040 assembler
- ▶ can compile to RAM or flash
- ▶ real-time operating system capabilities

Current limitations

- ▶ no USB serial support - requires UART connection
- ▶ does not support wireless yet

zeptoforth on GitHub

- ▶ repository: <https://github.com/tabemann/zeptoforth>
- ▶ wiki: <https://github.com/tabemann/zeptoforth/wiki>

Road map

Target audio hardware

- ▶ Pimoroni Pico Audio Pack
 - ▶ ~ \$16US plus shipping
 - ▶ requires an expander board for UART connection (~ \$9US)
- ▶ Waveshare Pico Audio Expansion Module
 - ▶ ~ \$20US plus shipping
 - ▶ includes speakers
- ▶ Waveshare Overall Evaluation Board
 - ▶ ~ \$50US plus shipping
 - ▶ includes 3.5 inch resistive touch screen
 - ▶ includes serial-to-USB adapter
 - ▶ includes microSD card adapter

Proof of concept (v0.2.5)

- ▶ direct digital synthesis / sine wave of any frequency
- ▶ maybe two oscillators and frequency modulation
- ▶ maybe “triangle” / “sawtooth” / “pulse” waves
- ▶ maybe a filter and envelope generator and low-frequency oscillator
- ▶ target date: 2023-03-17

First release (v0.5.0) - Software

- ▶ will re-scope project after proof of concept!
 - ▶ need to assess audio performance constraints
- ▶ all synthesis / audio I/O words
- ▶ goal is all synthesis algorithms in Csound 7
 - ▶ <https://flossmanual.csound.com>
- ▶ target date: 2023-05-29

Second release (v0.7.5)

- ▶ signal flow graph interpreter
- ▶ algorithmic composition tools
- ▶ target date: 2023-07-04

Full release (v0.9.0+)

- ▶ live performance user interface
- ▶ multiple Pico ensemble synchronization over wireless
- ▶ target date: 2023-09-04

CLAMS on the web

- ▶ GitHub: <https://github.com/AlgoCompSynth/CLAMS>
- ▶ blog: <https://www.algocompsynth.com/#category:CLAMS>
- ▶ this presentation: <https://github.com/AlgoCompSynth/CLAMS/blob/main/presentations/CLAMS-intro.pdf>

Me on the web

- ▶ Mastodon: <https://ravenation.club/@AlgoCompSynth>
- ▶ LinkedIn: <https://www.linkedin.com/in/znmeb>
- ▶ Bandcamp: <https://algotcompsynth.bandcamp.com>

References

- Anderson, D. P., and R. Kiuivila. 1991. "Formula: a programming language for expressive computer music." *IEEE Computer* 24 (7): 12–21. <https://doi.org/10.1109/2.84829>.
- Anderson, David P., and Ron Kuivila. 1989. "Continuous Abstractions for Discrete Event Languages." *Computer Music Journal* 13 (3): 11–23. <http://www.jstor.org/stable/3680007>.
- Blackwell, A. F., E. Cocker, G. Cox, A. McLean, and T. Magnusson. 2022. *Live Coding: A User's Manual*. Software Studies. MIT Press.
- Salazar, S., A. Kapur, G. Wang, and P. Cook. 2014. *Programming for Musicians and Digital Artists: Creating Music with Chuck*. Manning.