Stride on Saturn M7 for Interactive Musical Instrument Design

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ABSTRACT

This demonstration introduces the Stride programming language, the Stride IDE, and the Saturn M7 embedded audio development board. Stride is a declarative and reactive domain specific programming language for real-time sound synthesis, processing, and interaction design. The Stride IDE is a cross-platform integrated development environment for Stride. Saturn M7 is an embedded audio development board by Okra Engineering, designed around an ARM® Cortex®-M7 processor based microcontroller. It targets high-end multi-channel audio processing and synthesis with very low latency and power consumption. The microcontroller has a rich set of audio and communication peripherals, capable of performing complex real-time DSP tasks with double precision floating point accuracy.

This demonstration will showcase specific features of the Stride language, which facilitates the design of new interactive musical instruments. The Stride IDE will be used to compose Stride code and generate code for the Saturn M7 board. The various hardware capabilities of the Saturn M7 board will also be presented.

Author Keywords

Stride, Stride IDE, Saturn M7, Domain Specific Language, Declarative, Reactive, Interaction Design, Embedded, Microcontroller, Real-time, Digital Signal Processing

ACM Classification

C.3 Special-purpose and Application-Based Systems—Real-time and embedded systems, D.2.11 [Software Engineering] Software Architectures—Languages, H.5.5 [Information Interfaces and Presentation] Sound and Music Computing—Signal analysis, synthesis, and processing.

1. INTRODUCTION

During this demonstration we will present new software and hardware tools for designing new interactive musical instruments. We will introduce a domain specific programming language called Stride[1] and its dedicated integrated development environment called Stride IDE. We will use Stride to generate code for an embedded audio development board called Saturn M7 designed by Okra Engineering[1].

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2. THE STRIDE LANGUAGE

Stride[2] is a programming language for real-time sound synthesis, processing, and interaction design. Stride abstracts hardware resources and separates semantics from implementation. A wide range of computation devices can be targeted such as microcontrollers, system-on-chips, general purpose computers, and heterogeneous systems. Stride prompts the generation of highly optimized target code by allowing the user to control the frequency and location of computations.

3. STRIDE INTEGRATED DEVELOPMENT ENVIRONMENT

The Stride IDE is a cross-platform (Windows, Linux, OS X/macOS) integrated development environment for composing Stride code. The Stride IDE is built on the Qt[3] cross-platform application framework. Some of the features of the Stride IDE are: code highlighting, code auto-completion, code tooltips, error highlighting, on the fly documentation rendering, and a general purpose console.

The Stride IDE can be downloaded at:

`http://stride.audio/downloads/`

4. SATURN M7 EMBEDDED AUDIO DEVELOPMENT BOARD

The Saturn M7 is an embedded audio development board by Okra Engineering. The board is designed around a STM32F7[4] series microcontroller by STMicroelectronics[5]. The microcontroller has an ARM® Cortex®-M7 processor, running at 216 MHz. The board measures 78 by 110mm.

The board has been designed specifically for use with the Stride programming language and it can serve as a platform for the development of interactive musical instruments.

4.1 The Board

The Saturn M7 board is designed around the STM32F769 microcontroller. The processor has a double precision floating point unit, 2 Mbytes of embedded Flash memory, and

[1] `http://okra.engineering`
[2] `http://stride.audio`
[3] `http://www.qt.io`
[4] `http://www.st.com/en/microcontrollers/stm32f7-series.html`
[5] `http://www.st.com`

512 Kbytes of universal data memory. Key features of the board are:

- 16 Mbit of fast SRAM with 10ns access time
- 512 Mbit of Flash over a QUAD SPI interface
- High Speed OTG (Device/Host) USB over an external PHY transceiver
- Full Speed OTG (Device/Host) USB
- 10/100 BASE-T Ethernet with Precision Time Protocol (PTP)
- MIPI-DSI display interface
- Three dedicated Serial Audio Interface (SAI) data channels[6] with a master clock output
- Four S/PDIF inputs and S/PDIF outputs available on the SAI data channels
- Two half duplex I^2S peripherals with a master clock output
- One SPI port with hardware controlled chip select, three I^2C ports, and three UART ports
- SWD/SWO interface for programming and debugging

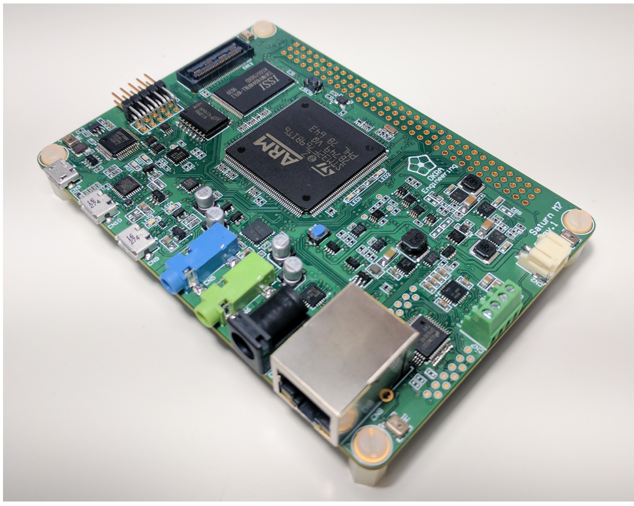

Figure 1: Saturn M7 by Okra Engineering

The board has a high performance Delta Sigma CODEC (32bit, 192KHz, 108dB S/N) with 2 channels of input and 2 channels of output. The inputs can be captured at 16, 20, 24, and 32 bit resolution at up to 192KHz, while output resolutions of 16, 24, and 32 bit at 192KHz are supported. The CODEC has high resolution filters for superior audio quality featuring short group delays.

The board also has 4 omni-directional MEMS microphones with an acoustic overload point of 120dB SPL, a 61dB signal-to-noise ratio, and -26dB FS sensitivity. The microphones respond to frequencies between 20Hz and 10KHz. They have a flat response between 100Hz and 5KHz ($\pm$1dB).

The board has a stereo class-AB headphone amplifier capable of driving 60mW into a 16 Ohm load. It also has a stereo class-D audio amplifier capable of driving 2.1W per channel into a 4 Ohm load. Both amplifiers are connected to the CODEC's output.

The board comes with a low jitter, 8 channel configurable clock synthesizer. It drives the audio peripherals and CODEC.

Clocks on multiple Saturn M7 boards can be synchronized down to 8ns over Ethernet through PTP.

[6] A fourth channel is shared with the QUAD SPI peripheral

The board has a 60 pin high speed header to interface with a TFT display with touch screen capability over MIPI-DSI. It also has a 96 pin header, which exposes the many digital and analog I/O pins and peripherals of the microcontroller.

The board can be powered over any of the USB ports, through a DC barrel connector, or a lithium-ion battery.

An on-board programmer and debugger is available through a USB interface, which can also be configured as a virtual COM port. The board can also interface with external programmers and debuggers.

5. BOARD COMPARISON

The Saturn M7's DSP performance compares favorably to the Axoloti[7] and Owl Digital[8] due to its processor's type (Cortex®-M7 vs -M4) and speed. The Saturn M7 performs floating point computations with double precision compared to single precision on the Axoloti and Owl Digital. Like the Owl Digital, the Saturn M7 has an external fast SRAM to perform memory-intensive algorithms.

Unlike the BELA[9], a cape for the BeagleBone Black[10], Saturn M7 is a standalone board. The number of analog I/O channels on the Saturn M7 can match and exceed those of the BELA by adding a dedicated daughter board. The Saturn M7 can support up to 32 channels of audio over SAI.

The audio CODEC on the Saturn M7 outperforms those found on these competing boards. It can also support a multi-touch TFT LCD screen.

6. DEMONSTRATION

During the demonstration we will show and discuss the following implementations:

- Matrix mixer with gain control: This highlights Stride's multi-channel and parallel statement capabilities.
- Waveform generator with amplitude and frequency modulation: Demonstrates reactive control in the Stride language
- Subtractive synthesizer: Shows how to build more complex signal graphs in Stride
- Vocoder: Demonstrates frequency domain processing within the Stride language

7. CONCLUSION

With this demonstration, we presented the synergy between the Stride programming language, the Stride IDE, and the Saturn M7 embedded audio development board to design new interactive musical instruments.

8. ACKNOWLEDGMENTS

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9. REFERENCES

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[8] http://hoxtonowl.com
[9] http://bela.io
[10] http://beagleboard.org