Switched-on Yampa

Programming Modular Synthesizers in Haskell

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  - **Signals**: time-varying values
  - **Signal Functions**: functions on signals
  - **Switching** between signal functions
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• Programming model:
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• Fun application! Useful e.g. in a class-room context?
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- Sound-generating and sound-shaping modules
- Supporting infrastructure:
  - Reading MIDI files (musical scores)
  - Reading SoundFont files (instrument definitions)
  - Writing result as audio files (.wav)
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Framework for programming modular synthesizers in Yampa:

- Sound-generating and sound-shaping modules
- Supporting infrastructure:
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  - Writing result as audio files (.wav)
- Status: proof-of-concept, but decent performance.
Example 1: Sine oscillator

\[ \text{oscSine :: Frequency} \rightarrow SF \ CV \ Sample \]
\[ \text{oscSine} \ f0 = \text{proc} \ cv \rightarrow \text{do} \]
\[ \text{let } f = f0 \times (2 \times \times \ cv) \]
\[ \text{phi} \leftarrow \text{integral} \leftarrow 2 \times \pi \times f \]
\[ \text{returnA} \leftarrow \sin \phi \]

\[ \text{constant 0} \gg \text{oscSine} \ 440 \]
Example 2: Vibrato

constant 0

⇒ oscSine 5.0

⇒ arr (*0.05)

⇒ oscSine 440
Example 3: 50’s Sci Fi

\[ \text{sciFi} :: SF () \ Sample \]

\[ \text{sciFi} = \text{proc} () \rightarrow \text{do} \]

\[ \text{und} \leftarrow \text{arr} \left( \ast 0.2 \right) \ll \text{oscSine} 3.0 \ast 0 \]

\[ \text{swp} \leftarrow \text{arr} \left( +1.0 \right) \ll \text{integral} \ast -0.25 \]

\[ \text{audio} \leftarrow \text{oscSine} 440 \ast \text{und} + \text{swp} \]

\[ \text{returnA} \ast \text{audio} \]
Envelope Generators

\[ \text{envGen} :: CV \rightarrow [(\text{Time}, CV)] \rightarrow (\text{Maybe Int}) \]
\[ \rightarrow SF (\text{Event } ()) (CV, \text{Event } ()) \]

\[ \text{envBell} = \text{envGen } 0 \ [(0.05, 1), (1.5, 0)] \text{ Nothing} \]
Example 4: Bell

\[ \text{bell} :: \text{Frequency} \rightarrow \text{SF} () (\text{Sample, Event}) \]
\[ \text{bell } f = \text{proc } () \rightarrow \text{do} \]
\[ m \leftarrow \text{oscSine} \left(2.33 \times f \right) \leftarrow 0 \]
\[ \text{audio} \leftarrow \text{oscSine} \ f \leftarrow 2.0 \times m \]
\[ (\text{ampl, end}) \leftarrow \text{envBell} \leftarrow \text{noEvent} \]
\[ \text{returnA} \leftarrow (\text{audio} \times \text{ampl}, \text{end}) \]
Example 5: Playing a C-major scale

\[
\text{scale} :: SF () (Sample, Event) \\
\text{scale} = (afterEach [(0.0, 60), (2.0, 62), (2.0, 64), \\
(2.0, 65), (2.0, 67), (2.0, 69), \\
(2.0, 71), (2.0, 72)] \\
\gg constant () \\
\&\& arr (fmap (bell \circ midiNoteToFreq)) \\
\gg rSwitch (constant 0)) \\
\&\& after 16 ()
\]
Example 6: Polyphonic synthesizer (1)

Sample-playing monophonic synthesizer:

- Read samples (instrument recordings) from SoundFont file into internal table.
- Oscillator similar to sine oscillator, except sine func. replaced by table lookup and interpolation.

SoundFont synthesizer structure:
Example 6: Polyphonic synthesizer (2)

Exploit Yampa’s switching capabilities to:

- create and switch in a mono synth instance in response to each note on event;
- switch out the instance in response to a corresponding note off event.
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Software and paper: www.cs.nott.ac.uk/~ggg