Faust audio DSP language in the Web

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Faust

Speed up audio application and plug-in development

Faust offers an abstract high-level notation to describe DSP algorithms in a concise and effective manner.
Audio applications designers have to deploy their work on a variety of platforms (Linux, OSX, Windows, Android, iOS, embedded devices, etc). One of Faust strong idea is to write the DSP once and easily deploy it on a wide number of systems.
Faust

Make Faust compilation technology widely usable

Faust compilation technology is accessible using the **online compiler**, the **embedded compiler library version**, or the **FaustWeb remote compilation API** that produces various target binaries.

FaustLive with FaustWeb access

Faust in Max/MSP (faustgen using libfaust.so)

Online compiler
Audio on the WEB

WEB technologies like **asm.js**, **Web Audio API** or **Web components** aim to change the way we design, publish and share musical applications. Using this technologies **procedural content** can now be shared and combined as easily as **multimedia content**!

Grame offers several Web technologies:

- **libfaust.js + asm.js target (emcripten + Faust backend)**
  : embeddable JavaScript/asm.js Faust compiler
- **FaustWeb** : remote multi-targets compilation API
- **Faust Playground** : simplifying Faust programs design
The **Web Audio API** is a high-level JavaScript API for processing and generating audio in Web applications:

- native optimized C++/assembly nodes
- JavaScript/asm.js **ScriptProcessor** nodes
- connected to create an audio generating/processing graph
How to generate **ScriptProcessor** nodes?

- they can be "manually written" in pure JavaScript
- or in asm.js for better performances (but this is difficult...)
- or automatically generated from DSP code already written in C/C++... (emscripten)
- or automatically generated from a Domain Specific Language
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Asm.js code generation (1)

**Asm.js** is developed by Mozilla along with **Emscripten**:

- **asm.js**: an extremely restricted subset of JavaScript that provides only strictly-typed integers, floats, arithmetic, function calls, and heap accesses (using typed arrays).
- **asm.js** variables, computation, return values types are annotated
- **asm.js** can easily be optimized
- future extensions like **SIMD.js** (vectorized types in JavaScript)
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Asm.js code generation (2)

```javascript
function GeometricMean(stdlib, foreign, buffer) {
  "use asm";

  var exp = stdlib.Math.exp;
  var log = stdlib.Math.log;
  var values = new stdlib.Float64Array(buffer);

  function logSum(start, end) {
    start = start|0;
    end = end|0;

    var sum = 0.0, p = 0, q = 0;

    // asm.js forces byte addressing of the heap by requiring shifting by 3
    for (p = start << 3, q = end << 3; (p|0) < (q|0); p = (p + 8)|0) {
      sum = sum + log(values[p>>3]);
    }

    return +sum;
  }

  function geometricMean(start, end) {
    start = start|0;
    end = end|0;

    return +exp(+logSum(start, end) / +((end - start)|0));
  }

  return { geometricMean: geometricMean };}
```

asm.js benchmark (2 to 3 times slower than native code...)

Exemple of asm.js module
Generating asm.js with Emcripten:

- Emcripten C/C++ to JavaScript (asm.js) compiler developed by Mozilla starting in 2011
- Facilitates the port of huge C/C++ codebase on the Web
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Asm.js code generation (4)

Asm.js backend in Faust compiler: produces the asm.js module + some pure JavaScript helper functions

......

function getValue(dsp, offset) {
  dsp = dsp | 0;
  offset = offset | 0;
  return +HEAPF32[dsp + offset >> 2];
}

function compute(dsp, count, inputs, outputs) {
  dsp = dsp | 0;
  count = count | 0;
  inputs = inputs | 0;
  outputs = outputs | 0;
  var output0 = 0;
  var fSlow0 = 0;
  for (i = 0; (((i | 0) < (count | 0)) | 0) && (i < count); i = (((i | 0) + 1) | 0)) {
    var output = (HEAP32[outputs + (0 << 2) >> 2] | 0);
    var output0 = +(+(4.65661e-10 * +(HEAPF32[dsp + 8 >> 2])));
    for (j = 0; (((j | 0) < (count | 0)) | 0) && (j < count); j = (((j | 0) + 1) | 0)) {
      var output = (HEAP32[outputs + (0 << 2) >> 2] | 0);
      var output0 = +(+(fSlow0 * +(HEAP32[dsp + 0 + (0 << 2) >> 2] | 0)))
    }
    HEAP32[dsp + 0 + (0 << 2) >> 2] = (HEAP32[dsp + 0 + (0 << 2) >> 2] | 0);
  }

  ......
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Asm.js code generation (5)

Static compilation chain (Faust DSP to asm.js) allows to generate self-contained HTML pages.

- using emscripten as an intermediate step :

- or using direct asm.js code generation
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JavaScript compilation : asm.js generation

Static compilation chain scripts :

- takes Faust DSP, compile it to asm.js, wraps it with additional JavaScript code to obtain a fully functional Web Audio node.
- wraps the Web Audio node in a HTML template to obtain a self-contained DSP node in the page

![Diagram of the compilation process]
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JavaScript compilation : asm.js generation

Dynamic compilation chain (libfaust.js + asm.js backend) allows to embed the complete compilation chain in the browser :

- first compile C++ libfaust for the Web (libfaust.js)

- compilation of an asm.js module happens at parse time of the source code. If parse time is triggered with ‘eval‘ then dynamic compilation occurs.
Benchmark of a CPU light application

Bird ported on the Web
Benchmark of a CPU heavy application

Yann Orlarey Ethersonik ported on the Web
Demo

- **faust2webaudioasm script**
  - From harpsichord.dsp to harpsichord.html

- **faust2asmjs**
  - Harpsichord
    - Thomas Cipierre & Laurent Pottier (Saint-Etienne, France)
  - foo-yc20
    - Sampo Savolainen (Helsinki, Finland)

- **libfaust.js**
  - FaustPlayground : create Faust patches online
Conclusions and perspectives

- still some issues with the Web Audio API: implementation, performances CPU/latency (audio workers: moving the ScriptProcessor nodes in the audio thread)
- really usable for serious work? still to be proved...
- but at least already usable for deployment, distribution, teaching purposes...
Softwares developed in different research projects are freely available under GPL/LGPL licenses:

- **Faust**: [http://faust.grame.fr](http://faust.grame.fr)
  - Faust: [git.code.sf.net/p/faudiostream/code](http://git.code.sf.net/p/faudiostream/code)
  - FaustLive: [git.code.sf.net/p/faudiostream/faustlive](http://git.code.sf.net/p/faudiostream/faustlive)
  - FaustWorks:
    [git.code.sf.net/p/faudiostream/faustworks](http://git.code.sf.net/p/faudiostream/faustworks)
  - FaustWeb:
    [git://git.code.sf.net/p/faudiostream/faustweb](http://git://git.code.sf.net/p/faudiostream/faustweb)
Recent publications on Faust

- Denoux, Letz, Orlarey, Fober 2014: *FAUSTLIVE: Just-In-Time Faust Compiler... and much more*. LAC 2014.
- Denoux, Letz, Orlarey, Fober 2014: *FaustLive un compilateur à la volée pour Faust ... et bien plus encore*, Journées d’Informatique Musicale, Bourges.