The software spectrometer `SpectralGpu`
Advancement Report 1

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The `SpectralGpu` *project is aimed at the development of a software spectrometer for the Radio wawelengths range using the computation power of the recently available GPU video boards.*

This memo reports the first progresses of the project up to 11/2012.

1 Functional Design

The `SpectralGpu` spectrometer gets its input from the digital receiver by means of a dedicated 10 Gbit Ethernet line. The receiver output data rate is tunable from 0.5 to 255 MS/s (10^6 samples/second) and the native format for each channel is a complex 8+8 bit signed integer (real ad imaginary parts as `signed chars`).

The desired spectral resolution is from 1 to 10 m/s. At a wavelength of 1 cm this translates to about 1 KHz. With a design band of 100MHz, this requirement translates in a 32–64K Fourier Transform.

2 Improvements

We obtained a consistent improvement in term of overall speed. We used many different approaches and the resulting success grad was mixed. We present here some of the work done.

A new Hardware We obtained a newer `ATI` board, the Radeon HD 7970. This new board offers some better characteristic over our previous top line one. In particular the standard core frequency rises from 800 to 950MHz and the core number rises from 1792 to 2048.

GPU memory transfer We investigated different approaches to the data transfer from the CPU memory space to the GPU engine. But while we gest some marginal improvements on slower cards, do no produced decisive benefits until now.

FFT buffer exchange We do not any more copy the partial FFT output buffer into the input one. Instead we re-spawn the partial FFT kernel with exchanged arguments. So we do not launch the **Swapper** kernel. This approach gives less speed boost than expected, as the rescheduling of kernel with different argument is a costly process. High end boards get a lesser bonus, probably due to their better coupling with the host CPU, but the speed-up can be evalued to be up to 10-20%.

Single precision We performed some tests on realistic simulations of radio data. We verified that having as source 8+8 bits complex data, and with all GPU internal computations in single precision we get rounding errors well below data noise. So we will use only single precision arithmetic inside GPU.

Convolution improvements We tested some different operations rearrangements for convolution operation. We still do not get any improvements over our present approach.

Native trigonometric functions The decision to use only single precision arithmetic permitted us to test the ATI *native* transform, that the use of these functions gives on the result an error well below input noise, while giving a 10-15% speed improvement.

3 Performances

We set up a test system to evaluate different boards performance on an uniform environment. We choose a Mint LTS 13 distribution and installed on this 32 bit system the ATI SDK 2.4 and the Ati Driver 12.6 - Catalyst 8.98. The CPU is a Intel Core i5-2400 3.1o GHz.

On `SpectralGpu` program we used also some parameter values suggested by previous experiences. The *local work size* is fixed to 64. This is probably sub-optimal on smaller boards.

We choose to have a FFT transform length of 32K. With this length we can use the more efficient radix-8 version of the algorithm. It is possible that a mixed radix FFT kernel can give a better performance for other lengths.

For the HD 6950 board, we needed to set the environment variables GPU_MAX_HEAP_SIZE to 50 and GPU_MAX_ALLOC_PERCENT to 90.

In the following tables we list the best results for each GPU and for the different numbers of simultaneous buffers in use. We use either mean processing time per input sample in ns, or the resulting sampling speed, in unit of 10^6 samples/s.

ATI GPU HD 7970 3GB

# buffers	Read speed (GB/s)	FFT time (ns)	GPU speed (MS/S)	**Total Speed (MS/S)**
256	2.69	0.47	590	433
512	3.55	0.48	710	590
1024	3.85	0.48	780	705
1536	4.28	0.48	805	755
2048	4.86	0.48	805	770

ATI GPU HD 7950 3GB

# buffers	Read speed (GB/s)	FFT time (ns)	GPU speed (MS/S)	**Total Speed (MS/S)**
256	2.69	0.58	550	410
512	3.52	0.58	655	550
1024	3.96	0.58	710	650
1536	4.24	0.58	730	680
2048	4.42	0.58	745	700

ATI GPU HD 6950 1GB

# buffers	Read speed (GB/s)	FFT time (ns)	GPU speed (MS/S)	**Total Speed (MS/S)**
256	4.38	0.87	460	400
512	5.03	0.88	490	450
1024	5.58	0.88	515	480

ATI GPU HD 7770 1GB

# buffers	Read speed (GB/s)	FFT time (ns)	GPU speed (MS/S)	**Total Speed (MS/S)**
256	2.65	1.80	260	220
512	3.50	1.80	280	260
1024	3.98	1.80	290	280