Programming Massively Parallel Hardware **Name:** *Gilles Souton*
Assignment 1
15-09-2022

Task 1

1.a Prove that a list-homomorphism induces a monoid structure

$\exists\ x, y, z$ where $h\ x = a, h\ y = b, h\ z = c$
so we can write:

$$(h\ x \circ h\ y) \circ h\ z \equiv \tag{1}$$
$$h(x +\!\!+\ y) \circ h\ z \equiv \tag{2}$$
$$h(x +\!\!+\ y +\!\!+\ z) \equiv \tag{3}$$
$$h(x +\!\!+\ (y +\!\!+\ z)) \equiv \tag{4}$$
$$h\ x \circ (h\ (y +\!\!+\ z))) \equiv \tag{5}$$
$$h\ x \circ (h\ y \circ h\ z) \equiv \tag{6}$$
$$\tag{7}$$

(4) Since the operator ++ is associative

1.b Prove the Optimized Map-Reduce Lemma

Task 2: Longest Satisfying Segment (LSS) Problem

See implementation file lssp.fut

Task 3: CUDA exercise, see lab 1 slides: Lab1-CudaIntro

We can see that the task run on the GPU is way faster than the one running on the cpu.

The operation here consist of mapping a function to each element of an array, therefore we can make use of threads to realize this operation in parallel. Each threads as an index associated in the array allowing to perform the mapping in parallel.

Speedup concerning the speedup, it's around 36 times faster...

```
[fpz747@a00333 cuda]$ ./wa1-task3
{
 - array_size: 753411
 - mem_size: 3013644
 - cpu_run: 100
 - gpu_run: 100
 - block_size: 256
}
---------- Executing task on CPU -----------
- Took 1641 microseconds (1.64ms)
--------------------------------------------

---------- Executing task on GPU -----------
{Block_size: 256, num_blocks: 2944}
- Took 45 microseconds (0.04ms)
--------------------------------------------

----------- Checking result ----------------
/ALID!
- Speedup 36
```

Task 4: Flat Sparse-Matrix Vector Multiplication in Futhark

I was not able to compile the futhark code on the server of the university… (but I was able to use nvcc to compile my task 3.. ?)

Both the OpenCL backend and CUDA backend were failing to find the library…

```
[fpz747@a00332 spMatVct]$ futhark cuda spMVmult-flat.fut
cc failed with code 1:
spMVmult-flat.c:32:18: fatal error: cuda.h: No such file or directory
 #include <cuda.h>
                  ^
compilation terminated.


If you find this error message confusing, uninformative, or wrong, please open an issue:
  https://github.com/diku-dk/futhark/issues
[fpz747@a00332 spMatVct]$ futhark opencl spMVmult-flat.fut
cc failed with code 1:
spMVmult-flat.c:38:19: fatal error: CL/cl.h: No such file or directory
 #include <CL/cl.h>
                   ^
compilation terminated.


If you find this error message confusing, uninformative, or wrong, please open an issue:
  https://github.com/diku-dk/futhark/issues
[fpz747@a00332 spMatVct]$
```

Explanations For an explanation of each line it can be found as comments in the spMVmult-flat.fut file