OpenCL exercise 1: Basics

Kaicong Sun

Task 1

- Calculate cosine function for a number of values on the GPU
- CPU code:

```
for (std::size_t i = 0; i < h_output.size (); i++)
    h_output[i] = std::cos (h_input[i]);
```

- Use one work item per value on the GPU

Steps

- Allocate memory on the device (`cl::Buffer` constructor)
- Initialize the memory on the device (`cl::CommandQueue::enqueueWriteBuffer()`)
- Copy the input data to the device (`cl::CommandQueue::enqueueWriteBuffer()`)
- Launch the kernel (`cl::Kernel::setArg()`, `cl::CommandQueue::enqueueNDRangeKernel()`)
- Copy the output data to the host (`cl::CommandQueue::enqueueReadBuffer()`)

Task 2

Add code for measuring

- Time needed for calculation on host
- Time needed for calculation on device
- Time needed for memory transactions

Speedup:

- Time on the CPU / Time on the GPU
- Time on the CPU / (Time on the GPU + Time for Memory transactions)

Compare the times using a Debug build and a Release build.

Task 3

Use `native_cos()` instead of `cos()` in the kernel and compare the performance.

Syntax: Memory allocation

Allocate memory:

```
cl::Buffer::Buffer(cl::Context context,
    cl_mem_flags flags, std::size_t size);
```

`context` = The context to use
`flags` = Normally `CL_MEM_READ_WRITE`
`size` = Number of bytes (not elements) to allocate

Syntax: Copying data

Copy data from CPU to GPU (global) memory:

```
cl::CommandQueue::enqueueWriteBuffer(cl::Buffer buffer,
    bool blocking, std::size_t offset, std::size_t size,
    const void* ptr, eventsToWaitFor = NULL,
    cl::Event* resultEvent = NULL) const;
```

`buffer` = The buffer to copy to
`blocking` = Wait until the copy operation has finished (normally `true`)
`offset` = Offset into the buffer (in bytes)
`size` = Number of bytes (not elements) to copy
`ptr` = Pointer to source data in CPU memory
`eventsToWaitFor` = Events which have to occur before the copy operation is started, normally `NULL`
`resultEvent` = Pointer to a variable where an event is stored (can be used for profiling)

Syntax: Copying data

Copy data from GPU (global) to CPU memory:

```
cl::CommandQueue::enqueueReadBuffer(cl::Buffer buffer,
    bool blocking, std::size_t offset, std::size_t size,
    void* ptr, eventsToWaitFor = NULL,
    cl::Event* resultEvent = NULL) const;
```

`buffer` = The buffer to copy from
`blocking` = Wait until the copy operation has finished (normally `true`)
`offset` = Offset into the buffer (in bytes)
`size` = Number of bytes (not elements) to copy
`ptr` = Pointer to destination in CPU memory
`eventsToWaitFor` = Events which have to occur before the copy operation is started, normally `NULL`
`resultEvent` = Pointer to a variable where an event is stored (can be used for profiling)

Syntax: Launching a kernel

Set parameters for a kernel launch:

```
cl::Kernel::setArg<T>(cl_uint index, T value);
```

`T` = The type of the parameter (e.g. `cl_int` or `cl::Buffer`)
`index` = 0-based index of the parameter
`value` = The value to use for the parameter

Launch the kernel:

```
cl::CommandQueue::enqueueNDRangeKernel(Kernel kernel,
    NDRange offset, NDRange global, NDRange local,
    eventsToWaitFor = NULL, cl::Event* event=NULL) const;
```

`kernel` = The kernel to launch
`offset` = Normally `0` or `cl::NullRange`
`global` = The overall number of work items
`local` = The number of work items per work group

Syntax: Kernel code

Declaring pointers:

```
__global int* foo; // Declare foo as a pointer to global mem.
__local int* foo; // ... to local memory
__private int* foo; // ... to private memory
__constant int* foo; // ... to constant memory
```

Get global index of the current work item in the x-direction:

```
size_t i = get_global_id(0);
```

Profiling

On the CPU:

```
Core::TimeSpan time1 = Core::getCurrentTime();
// Execute some code ...
Core::TimeSpan time2 = Core::getCurrentTime();

Core::TimeSpan time = time2 - time1;
std::cout << time << std::endl;
```

On the GPU:

```
cl::Event event;
queue.enqueue...(..., &event);
queue.finish(); // or enqueue*Buffer() with blocking = true

Core::TimeSpan time = OpenCL::getElapsedTime(event);
std::cout << time << std::endl;
```