Parallel Programming
Course Introduction for On-campus Students

Oregon State
University
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What this Course Is

This course is all about parallel programming on the "desktop" for applications that you are attempting to accelerate to improve user interaction and simulation and computational performance

The goals of this course are to leave you **"career-ready"** (i.e., both work-ready and research-ready) for tasks that require desktop parallelism, both on a CPU and a GPU. CS 475/575 topics include:

- Parallel computing: types, limitations
- Moore's Law, Amdahl's Law
- OpenMP
- Synchronization issues in parallel computing
- Cache issues in parallel computing
- SIMD
- GPU computing
- OpenCL
- CUDA

What this Course Isn't

This course is not about distributed processing. A lot of the same principles that we will discuss about the desktop do apply to distributed processing so this will still be useful.

However, if we have time, we will lightly touch on the Message Passing Interface, MPI, which *is* used in distributed systems.

Instructor

This course is being taught by:

Professor Mike Bailey
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Mike has had over 30 years experience in the computer graphics and high performance computing worlds. He has taught over 100 university classes to a total of almost 8,000 students. He has also taught over 90 professional short courses around the world.

In his spare time, he … oh, wait, there is none. Well, that's not quite true. He does like to read. In the spare time within all of that, he dabbles in K-12 outreach, particularly where he can apply computer graphics to it. Does that count as "spare time" or "more work"? ☺

Office Hours and Other Help

Sadly, I am a compulsive email checker. That is the best way to reach me. However, I am not necessarily a compulsive email-*returner*. I prioritize my email returns. Please do not email me over small things that you really can either look up or figure out for yourself (like "When is the assignment due?"). Those emails get low priority. The really serious concept email questions get high priority.

I am a compulsive telephone ignorer. That is not a good way to reach me consistently. I will return messages, but it might take a while. Email is better. This is not meant to be a disrespectful thing. It's just that I am in and out of my office a lot, and when I am in, there are usually students in there with me.

Until it is safe to hold on-campus Office Hours, I will hold Office Hours over the Internet on Zoom. I have my own "Zoom-Room". Its URL is:

https://oregonstate.zoom.us/j/8340727662

It's only available when I am there to "open it up" (not unlike a real room). To use this, you will need a microphone and speakers. I recommend a headset. They pickup less background noise than a microphone does and it gives you better sound than a speaker does. There are some nice ones on Amazon because of the popularity of gaming headsets. Just be sure to get one that is compatible with a plug on your computer.

I would love it if you also have a webcam, because then I can see you and get to know you a little better. And, because I often do these Office Hours from home, I sometimes get a little "help" from the following characters …

… Some Other Characters You Might "Meet"

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Callie

Callie is very shy. If you came over, she would hide under a bed. But, through Zoom, she won't know you are there. You might see her climbing around on my desk.

Zelda

Zelda is a 2-year-old puppy with bundles of energy. I am pretty sure you will see her run by the webcam during some home Office Hours. Her "puppy dog eyes" get her lots of snack food.

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What You Should Know on the Way In

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Above all, you should be a good C programmer. Being comfortable with function calls, arrays, for-loops, structures, arrays of structures, structures of arrays, pointers, and linked lists is a must. It is strongly suggested that you not use this class as an opportunity to learn C for the first time.

On the math side. You should know algebra. There will be times when we have an equation that solves for "Y given X" and I will ask, "What if we already know Y, how can we then go back and find X?". It would be good if you can do that.

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What We Will Be Covering

Note: this schedule is ***approximate***!
I will try to keep the schedule on the class web site up-to-date.

Week	Topics
1	Introduction. Syllabus. What this course is ... and isn't. The things we care about Parallel Programming for. Project notes: timing, graphing. (**This is really important.**) Simple OpenMP. Parallel programming background information. Von Neumann architecture.
2	Multithreading. Multicore. OpenMP: fork-join model Pragmas, what they do for you, what they don't do for you, OpenMP: parallelizing for-loops OpenMP: variable sharing OpenMP: Reduction. Not doing anything special vs. critical vs. atomic vs. reduction. Trapezoid integration. Timing. Speedup. Amdahl's Law. Parallel efficiency. Gustafson's observation. Moore's Law. What holds, what doesn't. Hyperthreading.
3	OpenMP: dynamic vs. static thread assignment. Chunksize. Mutexes. Barriers. Sections, tasks. OpenMP: tree traversal using tasks. Caches. Architecture. Hits. Misses. False sharing. Functional Decomposition

What We Will Be Covering

Week	Topics
4	Data Decomposition SIMD Vectorization: what it is, how to use it. Prefetching
5	Test Review GPU 101. Architecture. GPUs -- what they are good at. GPUs -- what they are not good at. Why.
6	Go over the test answers. CUDA: general concepts, program setup. CUDA: array*array multiplication CUDA: matrix*matrix multiplication

What We Will Be Covering

Week	Topics
7	CUDA: matrix*matrix block multiplication OpenCL: What is it? Diagram. How OpenCL is like CUDA and how it is different OpenCL library. Querying configurations.
8	OpenCL Events OpenCL Reduction. Looking at OpenCL Assembly Language. OpenCL / OpenGL Interoperability
9	OpenCL / OpenGL Interoperability
10	The Message Passing Interface (MPI) More information: books, periodicals, professional organizations, conferences. Class Evaluations Test #2 review

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Class Textbook

There is no textbook for this class. The course material will consist of handouts and notes taken while watching the videos.

If you need further reference material, there are a collection of links at the end of the class web site. You're not required to go look at any of these. They are just some links that I have found useful. They are there if you need them.

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Canvas vs Web Pages

I would *love* to do this whole class in Canvas-only. There is a lot to be said for consistency of interface. But, Canvas has certain things it can't do.

For example, you will use *Teach* (**http://engr.oregonstate.edu/teach**) to turn in your assignments. Because I can write scripts behind this system to extract parts of your submissions, I can grade them, and give you feedback a lot faster. Canvas will not let me do that.

So, we will use Canvas for a lot of things, but not all.