

CMSE401

Methods in Parallel Programming

Dirk Colbry, Michigan State University



Department of Computational Mathematics Science and Engineering

Est. 2015

- Jointly operated by Colleges of Natural Science and Engineering
- Composed of 25-30 FTEs, including some current MSU faculty and a larger number of **new hires**.
- Most faculty will have joint appointments across campus.
- Faculty focus on data science and large-scale and high-performance computation
- Faculty are incentivized to engage in cross-discipline and cross-college research collaborations



Computational science addresses the construction of mathematical models and quantitative analysis techniques and using computers to analyze and solve scientific problems.

Foundation:

Discipline leverages:

1. Application knowledge
2. Computer science
3. Mathematics

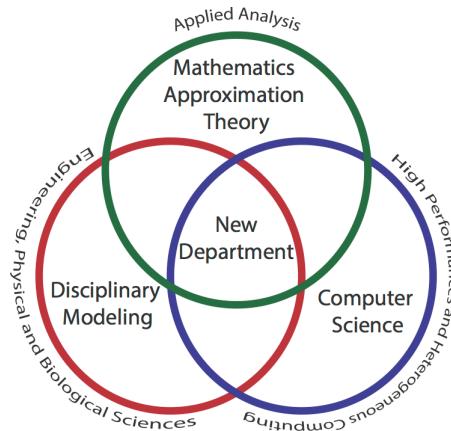
To develop new methods for investigating complex problems through computation.

Impact:

Analysis of complex experiments;
virtual prototyping;
virtual laboratory;
etc...



<http://cmse.msu.edu>



New Graduate Recruitment Director

- SEND ME YOUR BEST STUDENTS!!!!
- If you do, I will send you mine!!

Fall 2019 – CMSE401

- Completely new prep (with the help of this group last year).
- Need to put materials in a format that are easily transferable to new faculty.
- 15 week semesters
- Only 18 students this first time
- All Undergrad except one (We already have a graduate course)
- Unintentionally competing with a parallel course in CSE.
- Overall feedback from students is extremely positive.

Major Topics Covered

<https://tinyurl.com/CMSE314-Schedule>

- Navigating a shared computing system (ssh/BASH)
- Single Processor optimization and Pleasantly Parallel (C/C++)
- Shared Memory Parallelization (OpenMP)
- Accelerators (CUDA)
- Shared Network Parallelization (MPI)

Overarching Goal

Students coming out of CMSE401 should be able to walk into any lab on campus and help faculty get experiments running on an HPC, profile and benchmark them and help them run faster using parallel methods.

Planning board



CMSE401 - Format

- Flipped classroom
 - The week before students are given pre-class assignments that include readings and videos that they need to complete before class.
 - In-class we try to do hands-on activities
- Homework
 - Every two weeks an individual homework assignment was due.
- Exams
 - Two mid-terms and a final. All open network exams.
- Student Projects
 - Multiple deadlines throughout the semester ending in a final presentation.

All assignments were written up using Jupyter Notebooks

- Why Jupyter Notebooks? Isn't that Python? What does that have to do with High Performance Computing?
- Jupyter Notebooks are NOT an IDE!
- Jupyter Notebooks are a communication tool.
 - Textbook
 - Webpage – feedback forms, videos, images
 - Word Document
 - Equations
 - Code (That runs)
- Teaching is about communication between instructor and students.

Jupyter Examples

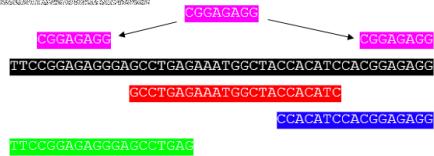
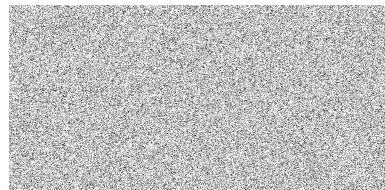
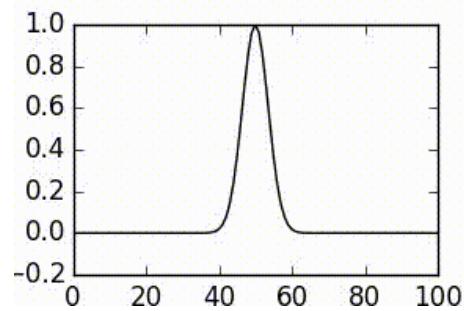
Some fun in-class activities

- We built and tested a BCCD cluster out of MacBook's running virtualBox
- Tour of the local HPC system
- Parallel Matrix Multiplication activity
 - Everyone is a process. How fast can we multiple two matrixes using the whiteboard?



Homework examples

- 1D/2D wave equation
- Agent Based Models
- Genomics
- Image Analysis



Projects

Stage 1

- Identify a demonstration software used in research.
- If needed Install the software on the HPC and write up an example that can be used by others in the class.

Stage 2

- Right or modify an existing code to be parallel or change the type of penalizations or input parameters.
- Benchmark something.

Example Student Projects

- Ising Model Optimization
- Numerical Relativity with Numba
- MPI POISSON EQUATION with MPI4PY
- OSCAR (Operational Research in Scala)
- Utilizing TensorFlow for Machine Learning in Biomedical Imaging
- Parallel Optimization of Sabermetric Quantifier
- Optimizing Garfield++ For Use In Simulating A Nuclear Detector
- Parallel Optimization in FLASH
- A Charm++ Parallel Stock Market Simulator
- Breast MRI Classification using TensorFlow
- Classifying Dog and Cat Images using TensorFlow
- Penalization of TDCI

Sharing my notebooks

- Happy to privately share tgz file with other instructors
- Not ready for anyone to post assignments online
- I want your stuff too. Let me know how you use it.
- Credit where credit is due.

Questions?

colbrydi@msu.edu