Lec 0: Course Logistics

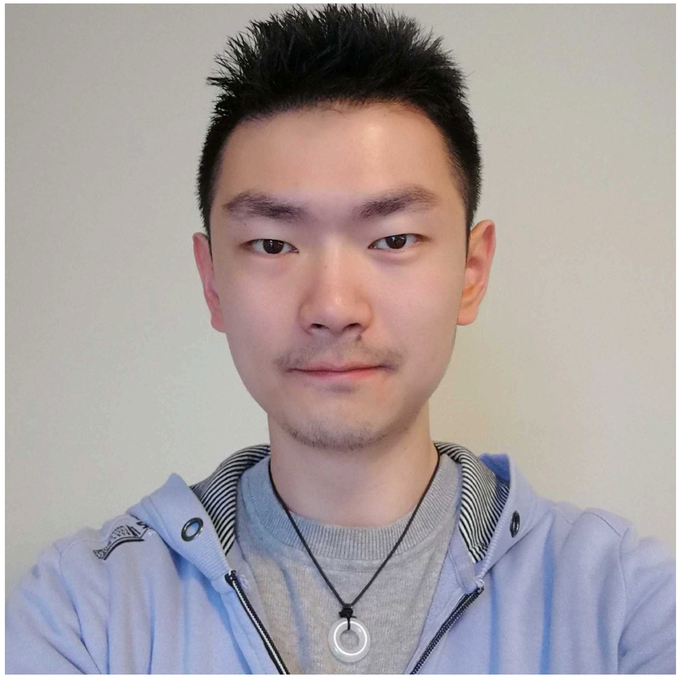
15-369/669/769: Numerical Computing

Instructor: Minchen Li

Course Staff

Instructor

- Minchen Li
  - Assistant Professor, CSD
  - minchenl@cs.cmu.edu
  - Office hour by appointment



Course Staff

Teaching Assistant

- TBD
  - We need at least 20 students registered to have a TA
  - Please ask your friends to register :)

Now it’s your turn to introduce yourself!

What’s your name?

What year and program are you in?

Anything else you’d like to share?

Why Numerical Computing?

- Solves complex problems that have no closed-form solutions.
- Simulate complex processes in science and engineering.
- Enables scalable data and ML algorithms.
- Links mathematical theory to practice.
- Builds computational and algorithmic skills.

The potentials of numerical computing are limitless!

Why Numerical Computing?

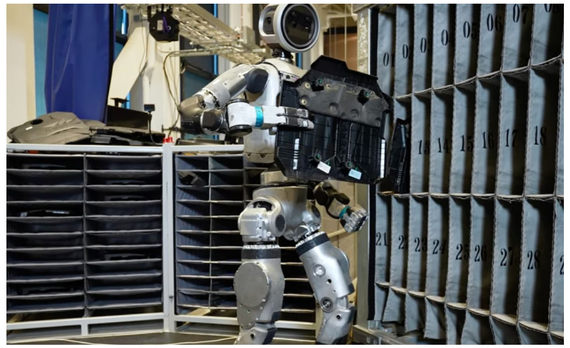
Limitless Potentials

Next-Level Entertainment & Social

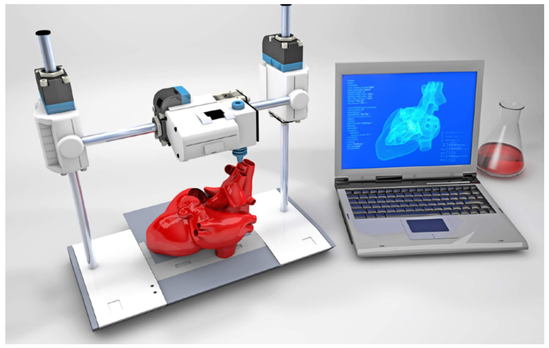
Immersed Education & Training

Virtual Try-On

Digital Twin Factory



Robot Learning



Computational Fabrication

Virtual Surgery

More to be explored by you!

Why Numerical Computing?

Fundamental Challenges

- Trade-offs, between
  - Computational costs
  - Quality of results, e.g. robustness, accuracy, etc.
- Data acquisition, e.g.:
  - Data instances
  - Model parameters

Tentative Syllabus

Schedule

- 20 lectures in total (excluding this one)
  - 2 for each assignment
- In-class midterm and final exams (+ in-class reviews)
- No class:
  - Labor Day,
  - Fall Break, and
  - The Thanksgiving **WEEK**!

- **Week 1**
  - (Aug 25) Lec0: Course Logistics
  - (Aug 27) Lec1: Mathematics Review
- **Week 2**
  - (Sep 1) *Labor Day, no class*
  - (Sep 3) Lec2: Numerics and Error Analysis
  - A1 due Sep 7 at 23:59 ET
- **Week 3**
  - (Sep 8) Lec3: Linear Systems and the LU Decomposition
  - (Sep 10) Lec4: Designing and Analyzing Linear Systems I
  - A2 due Sep 14 at 23:59 ET
- **Week 4**
  - (Sep 15) Lec5: Designing and Analyzing Linear Systems II
  - (Sep 17) Lec6: Column Spaces and QR
  - A3 due Sep 21 at 23:59 ET
- **Week 5**
  - (Sep 22) Lec7: Eigenvectors
  - (Sep 24) Lec8: Singular Value Decomposition
  - A4 due Sep 28 at 23:59 ET
- **Week 6**
  - (Sep 29) Lec9: Nonlinear Systems
  - (Oct 1) Lec10: Unconstrained Optimization
  - A5 due Oct 5 at 23:59 ET
- **Week 7**
  - (Oct 6) Midterm Review
  - (Oct 8) In-Class Midterm Exam
- **Week 8**: *Fall Break, no classes*
- **Week 9**
  - (Oct 20) Lec11: Unconstrained Optimization
  - (Oct 22) Lec12: Constrained Optimization
  - A6 due Oct 26 at 23:59 ET
- **Week 10**
  - (Oct 27) Lec13: Iterative Linear Solvers
  - (Oct 29) Lec14: Specialized Optimization Methods
  - A7 due Nov 2 at 23:59 ET
- **Week 11**
  - (Nov 3) Lec15: Specialized Optimization Methods
  - (Nov 5) Lec16: Interpolation
  - A8 due Nov 9 at 23:59 ET
- **Week 12**
  - (Nov 10) Lec17: Integration and Differentiation
  - (Nov 12) Lec18: Ordinary Differential Equations
  - A9 due Nov 16 at 23:59 ET
- **Week 13**
  - (Nov 17) Lec19: Partial Differential Equations
  - (Nov 19) Lec20: Partial Differential Equations
  - A10 due Nov 23 at 23:59 ET
- **Week 14**: *Thanksgiving, no classes*
- **Week 15**
  - (Dec 1) Final Review
  - (Dec 3) In-Class Final Exam

Tentative Syllabus

What is this course about? — Style

- We will focus on introducing the main concepts, basic methods, and a bit about the practicality and state-of-the-art methods.

- Some discussions on key **derivations**, **algorithms**, and **implementations.**

- We will also briefly mention existing open-source code/libraries.

Tentative Syllabus

What is not covered in this course?

- Hardcore parallel computing, e.g. GPU programming
- Large-scale numerical methods
- Hardcore physics-based simulation (numerical solutions to PDEs)
- Hardcore stochastic methods, e.g. Monte-Carlo PDE solvers

- Some of these are covered in
  - 15-763: Physics-Based Animation of Solids and Fluids
  - 15-327: Monte Carlo Methods and Applications

Recommended Prerequisite

- Programming (Python)
  - numpy, pygame
- Vector Calculus
  - vector derivatives, e.g. gradient, divergence, curl
- Linear Algebra
  - Basic vector/matrix operations, matrix factorization, linear solvers, …

Grading

- Assignments: 75% (7.5% each)
  - Written + Programming
  - Designed to be completed within ~5 hours each
  - 5 grace days in total, at most 2 can be used for each assignment
  - Posted and submitted on Canvas.
  - Make Piazza posts if any questions!
- In-Class Midterm Exam: 10% [Oct 8]
- In-Class Final Exam: 15% [Dec 3]

Each unused grace day will be 0.4% bonus points added to the final grades!

— 1 letter-size cheat sheet allowed!

Online Platforms

- Announcements and Online Q&A: **Piazza**
  - piazza.com/cmu/fall2025/15369669
  - Access code: numerical
- Grades: **Canvas**
  - canvas.cmu.edu/courses/49693
- **Course website:** general info, lecture slides, resources
  - cs.cmu.edu/~15369-f25/

AI Tools Allowed With Proper Citation

- Mandatory Appendix for AI Tool Usage
- Citations and Academic Integrity
  - CMU's academic integrity policy
- Accuracy and Responsibility

Resources

- Textbook (not mandatory)
  - Solomon, J. (2015). Numerical algorithms: methods for computer vision, machine learning, and graphics.
- More graphics courses at CMU
- Physics Simulation in Visual Computing (with Javascript tutorial)
- Christopher Batty's physics-based animation site
- Open access to ACM SIGGRAPH-sponsored content
- Ke-Sen Huang's page on CG papers

Questions?

Image Sources

- https://www.theverge.com/2024/10/30/24283592/boston-dynamics-atlas-robot-autonomous
- https://www.3ds.com/make/solutions/industries/medical-3d-printing
- https://r-wong253249-sp.blogspot.com/2013/11/pose-to-pose-and-frame-by-frame-research.html
- https://dreamfarmstudios.com/blog/what-is-3d-rigging/
- https://www.physicsbasedanimation.com/