CSCE 440/840
Numerical Analysis I
Course Syllabus

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Outline

- Course Overview
- Course Objectives
- Topics and Timeline
- Assignment Structure
- Grading Policy

What is Numerical Analysis?

- Numerical analysis is the study of algorithms that use numerical approximation for problems of mathematical analysis.

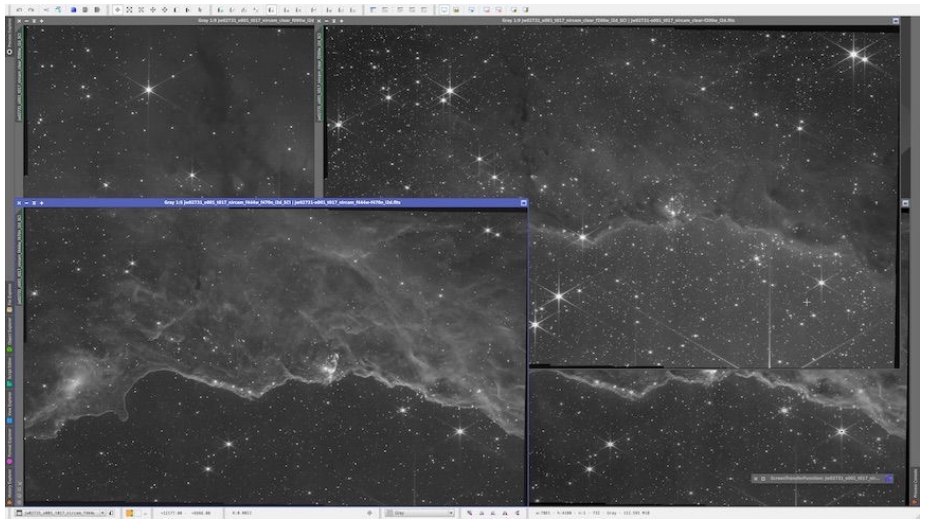
- Numerical analysis deals with limits, differentiation, integration, infinite series, etc.

Why Numerical Analysis?

- It investigates and provides accurate solutions to real-life problems in science, engineering, biology, astrophysics, finance, and so on
- Modern computers serve as an efficient tool to approximate a solution when an exact solution is not practical to find
- It is crucial for us to understand the ideas behind algorithms to make sense of why we have the solutions and the reason for errors
- Applicable areas of numerical analysis
  - Aircraft simulations
  - Bridge design and structural integrity
  - Weather prediction, etc.

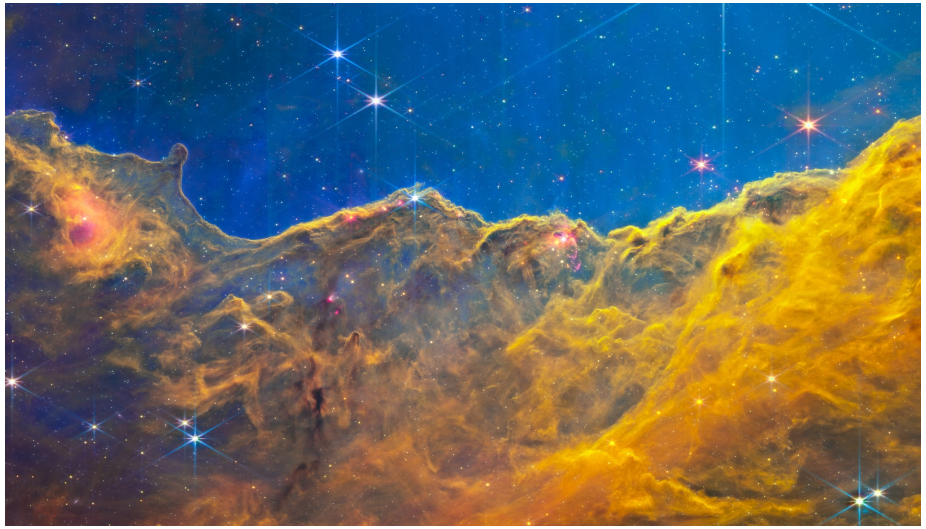
An Application in High-Resolution Image Processing

- James Webb Space Telescope (JWST) is the largest optical telescope launched in Dec. 2021 by NASA
- The raw data transmitted back from JWST are publicly available, but need post-processing
  - An example of Carina Nebula on the right
- Researchers use image processing algorithms to turn raw data into beautiful images
- Algorithms in numerical analysis are involved in some image processing tools, such as interpolation, extrapolation, etc.
  - We will have a chance to explore these algorithms this semester



Raw data (upper)

After processing (lower)

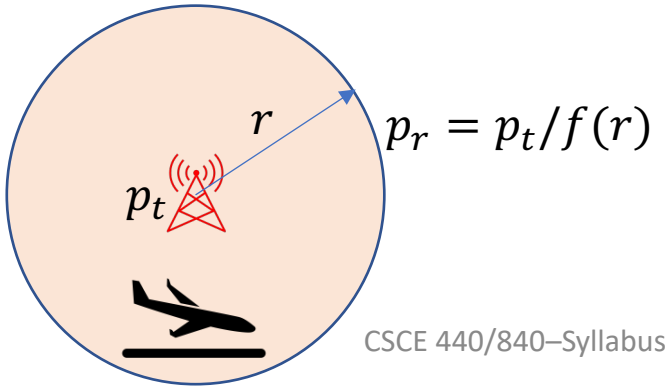


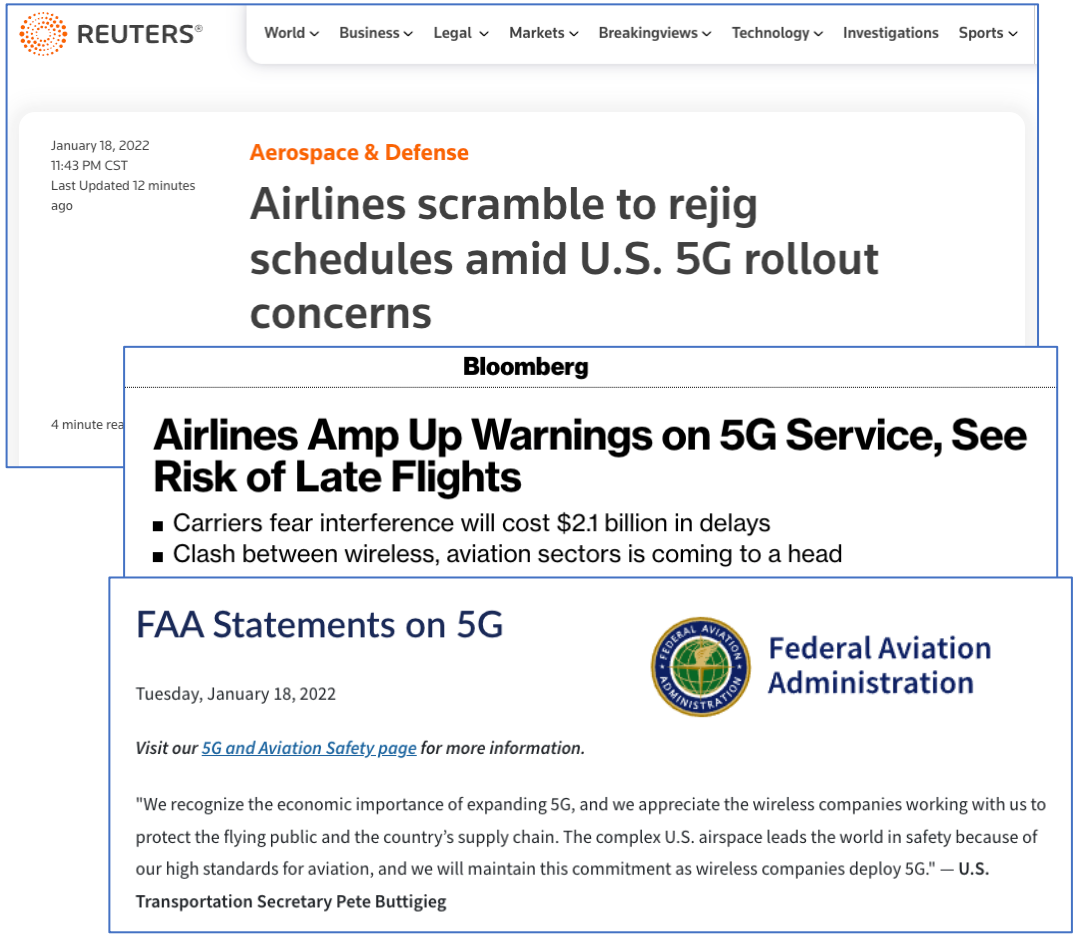
Source: https://www.galactic-hunter.com/post/jwst-data

An Application in Wireless Communication

- In 2022, major concerns from airlines about 5G signal interference with altimeter readings
  - Transmit power p_t from nearby cellular towers might affect the reading accuracy

- Suppose the maximum allowable power from cellular tower interference is $p_{i,max}$, how far should the tower be away from the airport so that it won't violate the FAA regulations?
  - Equivalent to $g(r) = p_r - p_{i,max} = 0$
  - Use Newton's method to find r iteratively

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World Business Legal Markets Breakingviews Technology Investigations Sports

January 18, 2022
11:43 PM CST
Last Updated 12 minutes ago

Aerospace & Defense

Airlines scramble to rejig schedules amid U.S. 5G rollout concerns

Bloomberg

Airlines Amp Up Warnings on 5G Service, See Risk of Late Flights

- Carriers fear interference will cost $2.1 billion in delays
- Clash between wireless, aviation sectors is coming to a head

FAA Statements on 5G

Federal Aviation Administration

Tuesday, January 18, 2022

Visit our 5G and Aviation Safety page for more information.

"We recognize the economic importance of expanding 5G, and we appreciate the wireless companies working with us to protect the flying public and the country's supply chain. The complex U.S. airspace leads the world in safety because of our high standards for aviation, and we will maintain this commitment as wireless companies deploy 5G." — **U.S. Transportation Secretary Pete Buttigieg**

Course Overview

- This is an undergraduate and graduate level course
  - Expectations for undergraduate and graduate students will be slightly different (e.g., midterm exam questions will be slightly different, topic selection for final project, etc.)

- As a 400/800-level course, students are expected to have basic understanding on linear algebra and calculus as prerequisites

- Course materials
  - Textbook: Richard L. Burden *et al.*, Numerical Analysis (Tenth Edition), Cengage Learning, 2016.
  - All algorithms needed in this course are available from the textbook

Course Objectives

- Mastery of fundamentals of **Number Representation** and **Error Analysis**
- Mastery of the basic methods of **Solutions of Equations with One Variable**
- Mastery of **Interpolation and Polynomial Approximation**
- Mastery of **Numerical Integration and Differentiation**
- Familiarity with **Spatial Interpolation and Approximation**
- Familiarity with **Systems of Linear Equations**
- Exposure to **Ordinary Differential Equations**
- Exposure to **Smoothing of Data and Method of Least Squares**
- Exposure to **Software Verification**

Course Topics

- Principles of numerical computing and error analysis
- Root finding, systems of equations, interpolation, numerical differentiation, and integration
- Differential equations
- Modeling real-world engineering problems on digital computers
- Effects of floating-point arithmetic
- Basic machine learning algorithms from the perspective of numerical analysis

Class Schedule

- Monday, Wednesday, and Friday, 11:30 AM–12:20 PM
- Location: AVH 110

- Office hour: Monday 12:30 PM–1:30 PM or by appointment
- Location: Avery 364
- Alternative online office hour: via Zoom at https://unl.zoom.us/j/7271015326

About the Instructor

- Prof. Shuai Nie
  - Assistant Professor, School of Computing @ UNL, since August 2021
  - Ph.D. in ECE, Georgia Institute of Technology, May 2021

- Research interests: millimeter wave and terahertz band communications, signal processing in multi-antenna systems, Internet of Things.

- Homepage: https://cse.unl.edu/~snie/

- Office Hour: 364 Avery Hall, 12:30 pm—1 pm, or via Zoom https://unl.zoom.us/j/7271015326

Teaching Assistant

- Ms. Nedasadat Taheri (Ph.D. Student in School of Computing)
- Email: ntaheri2@huskers.unl.edu
- Office Hour: Wednesdays 12:30 pm–1:30 pm via Zoom at https://unl.zoom.us/j/93994945822

Course Website

- Canvas will be used as the primary course website
  - Announcements
  - Lecture notes
  - Additional course materials
  - Assignment submissions
  - Assignment grades
  - Communication

- Instructional Continuity Plans for when In-Person Classes are Canceled
  - If in-person classes are canceled, you will be notified of the instructional continuity plan for this class by Canvas Announcements

Course Components and Grade Scale

- Homework 20%
- Labs 30%
- Midterm Exams 25%
- Final Project 25%

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
95–100	90–94	87–89	84–86	81–83	77–80	74–76	70–73	67–69	64–66	60–63	57–59	0–56

More About Assignments

- **Homework Assignments** (20%)
  - ~4 assignments, 5% each, ~3 questions in each assignment
- **Labs** (30%)
  - ~6 labs, 5% each, 1–2 questions in each lab
  - Labs are in-class pen-and-paper problems on Canvas
  - All labs will be on Fridays (will announce lab days in advance)
- **Midterm Exams** (25%)
  - Closed-book exams in this classroom during class time
  - A letter size (A4 size) cheat sheet and a calculator are allowed
  - ~3 questions in each exam

More About Final Project

- Group project with maximum of 2 students per group
- Sample topics from previous years
  - COVID-19 case prediction (University Honors Program)
  - Annual rainfall forecast
  - Bitcoin price prediction
  - Quality improvement of digital sound
  - ……

Grading Policy

- Homework assignments should be submitted in PDF format via Canvas. It is highly recommended that you use LaTeX to organize your write-up. Please be advised that handwritten and scanned submissions will not be accepted.
- The final project is evaluated based on a final presentation, a project report, and a runnable source code package with a clear README file.
- All assignments and exams, except the final project, are individual assignments and not for collaboration.
- For homework and lab assignments, late submissions (after solutions are posted on Canvas) will result in a 10% deduction per day.
- No make-up tests will be given.
- Students are responsible to make sure assignments are submitted successfully—corrupted files that cannot be read are considered as late submissions.
- A bonus point of 1% will be applied upon completion of the course survey at the end of this semester.

Grading Rubric for Final Project Report

- Should clearly identify the selected topic
  - A list of candidate topics will be provided, but just for suggestions
  - Creative topics (application-oriented, or theoretical) are highly encouraged
- Meet page length requirement (minimum 3 pages)
- Follow technical writing rules
  - References should follow IEEE Transactions format
  - Figures and tables should have clear captions and formats
  - Comprehensive how-to instructions: http://ieeeauthorcenter.ieee.org/wp-content/uploads/How-to-Write-for-Technical-Periodicals-and-Conferences-1.pdf

Grading Rubric for Final Project Presentation

- Clearly identify the problems and explain solutions
- Q&A after presentation
- Meet time limit (20-minute presentation + 3-minute Q&A)

Important Dates

- **Homework Due Dates** (Spring break: March 10–17)
  - HW 1: February 7
  - HW 2: February 21
  - HW 3: March 6
  - HW 4: March 27

- **Tentative Exam Dates**
  - Midterm 1: March 1
  - Midterm 2: April 5

- **Final Project Dates**
  - Topic selection and team formation (max. 2 students per team): by March 25
  - Final presentation dates: The weeks of April 22 and April 29
  - Slides due one week prior (we can iterate to improve the structure & content)
  - Final package submission: May 10

MATLAB Installation

- Information about the MATLAB installation
  - https://itprocurement.unl.edu/matlab
- It is strongly recommended to install MATLAB or create an account to be able to use MATLAB online before the first homework assignment
- There will be lectures that involve MATLAB practice
- Final projects might also involve MATLAB simulations

Writing Resources at UNL

- Writing Center
- https://www.unl.edu/writing/online-writing-center-services

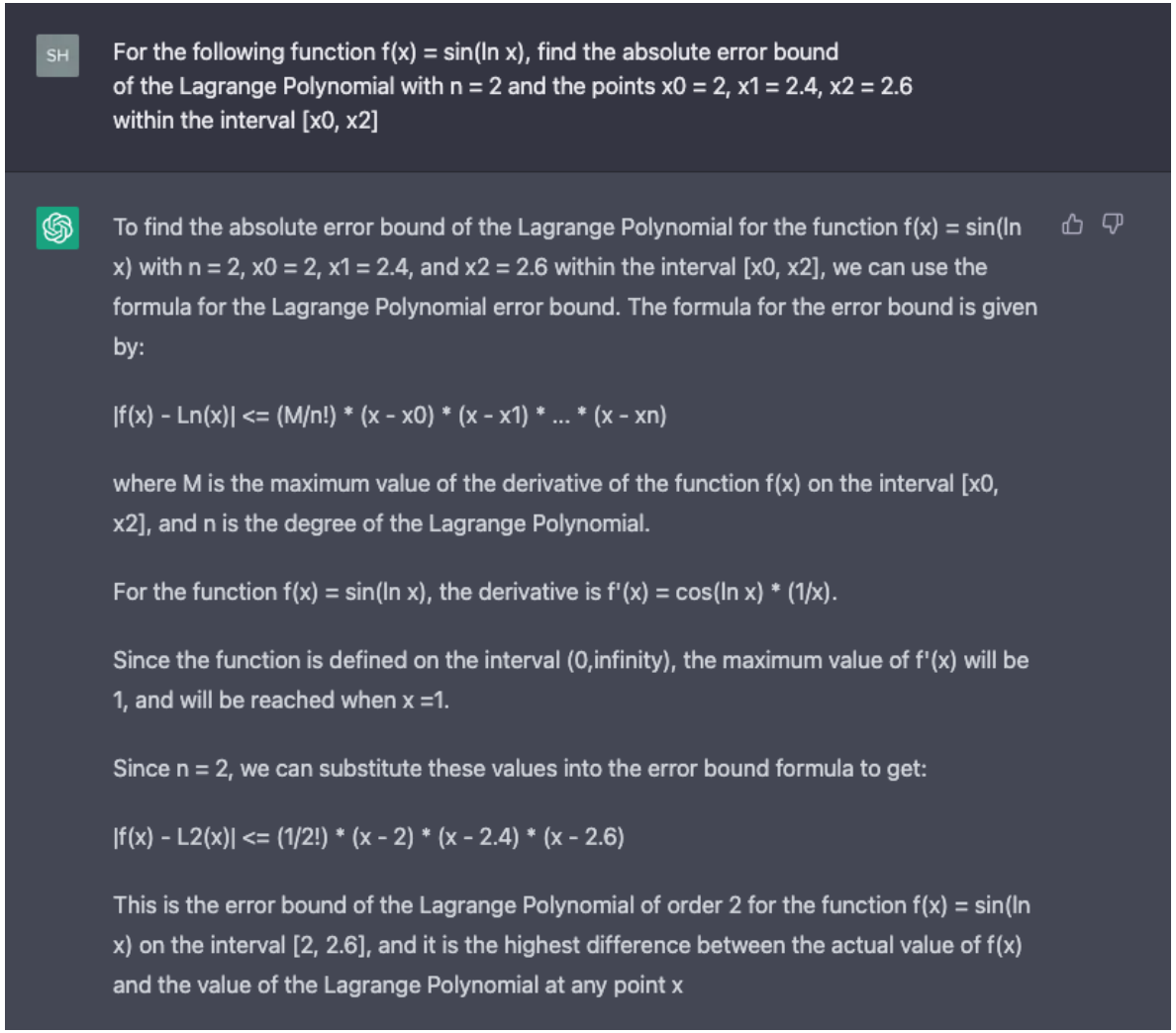
- Some books for technical writing
  - Strunk, William. *The elements of style*. Penguin, 2007.
  - Stephen B. Heard. *The Scientist's Guide to Writing: How to Write More Easily and Effectively throughout Your Scientific Career.* Princeton University Press, 2016.

Some Other Notes

- Accommodations for Students with Disabilities
  - Services for Students with Disabilities (SSD) office
  - If you need assistance, please let me know as soon as possible
- Counseling and Psychological Services
  - UNL offers a variety of options to students in dealing with stress and adversity.
- Academic Integrity
  - All homework assignments, programs, and exams must represent your own work unless otherwise stated. No collaboration with fellow students, past or current, is allowed unless otherwise permitted on specific assignments or problems. The Department of Computer Science & Engineering has an Academic Integrity Policy. All students enrolled in any computer science course are bound by this policy. You are expected to read, understand, and follow this policy. Violations will be dealt with on a case-by-case basis and may result in a failing assignment or a failing grade for the course itself.
  - A plagiarism-detecting mechanism will be implemented during assignment grading

Let's Talk About ChatGPT…

- ChatGPT is known to be bad at math
  - Example 1, Example 2, Example 3, ……
- Let's try asking ChatGPT one sample lab question from our class…
- The bottom line: if you fully trust ChatGPT, you may lose most points…and may not learn things



Example of asking ChatGPT a lab question

What to Expect on Wednesday (Jan. 24)?

- We will discuss the topics of round-off errors and computer arithmetic

- Pre-class reading: Section 1.2 in Chapter 1