CARNEGIE MELLON UNIVERSITY

24658/42640: Image-Based Computational Modeling and Analysis

Project 2

Task

2-3 students (preferably 2 students) form a team. Each team picks one topic and finds at least 6 related technical papers (different from lecture notes) from conference proceedings and technical journals. If you are interested in other research topics related to this class, please discuss with me. You can choose one from the following two options to work on your topic.

- Option 1: Survey

Read these papers, summarize problems, categorize previously proposed approaches, discuss the pros and cons of each approach, give discussion and observation, and wrap up with future directions that you think might be promising.

- Option 2: Programming

From the 6 papers, you can choose one algorithm, implement it, and design some examples to test your code. Finally, summarize your results into one report and submit along with your codes.

Prepare a report (8-12 pages) and give a presentation (10 minutes + 2 minutes Q&A) to the class.

Each group will also prepare a one-page summary of another group's presentation. I will tell you which group you are responsible for.

Evaluation

The project is worth 30% of your final grade. The half-page proposal is worth 3%, the written report is worth 12%, the oral presentation is worth 12%, and the one-page summary of another presentation is worth 3%. You are free to divide up the tasks in your group. Each group member will get the same grade.

Choice of topic

Ideally, your project will be on a topic related to your research and/or general interests. Here are some suggested topics you may want to investigate:

1. Combining machine learning and LLMs with image processing, meshing or physics-based simulations
2. Physics-based and data driven modeling of vascular modeling in liver, limb or head
3. Neurite growth and material transport simulations in complex neuron trees
4. Image-based geometric modeling and mesh generation
5. All-hexahedral and hex-dominant mesh generation with feature preservation
6. Delaunay triangulation and tetrahedral mesh generation with guaranteed quality
7. Mesh quality improvement using optimization

8. Polycube-based spline modeling for isogeometric analysis
9. Patient-specific cardiovascular blood flow simulation
10. Biomolecular from atomic resolution data of protein data bank and electrostatic potential analysis

For many of these topics, *Geometric Modeling and Mesh Generation from Scanned Images* is a great place to look. You are also welcome to use other reference sources (the internet, books, research papers, etc). I would rather that people not choose the same topic as others, but will deal with this issue once everyone has told me what they want to do. As long as you can pose a good question, which can be investigated in the time frame of the course and with your abilities, your topic should be suitable.

Timeline

Nov 3 (Mon): A half-page proposal of your planned work is due at 11:59PM (submit to Canvas). Please include the title of your topic and the group member name(s) in your proposal.

Nov 5 (Wed): Meeting with each group (10 minutes) to discuss their topics. A sign-up sheet will be available online on Nov 2.

Nov 24 (Mon), Dec 1 (Mon) and Dec 3 (Wed): Presentations will take place in class. Each group will give a 10-minute talk with 2 minutes of questions. Your talk should contain a description of the problem you are studying, the analysis plan you are following, and some preliminary results. You will be graded on the presentation and the content. I hope that the questions and feedback from other students will help in the preparation of the final report. Submit the presentation materials to Canvas 20min before the presentation class starts.

Dec 5 (Fri): Your 1-page summary of another presentation is due by 11:59PM. Please submit the electronic version to the Canvas.

Dec 8 (Mon): Final reports are due by 11:59PM, please submit the electronic version to the Canvas. Your report should be 8-12 pages. The organization is up to you. The use of tables, figures, images, etc, is strongly encouraged. The report should address the following issues:

- The motivation behind the project (i.e., what is the mechanical engineering system you are studying).
- Specific details about what numerical techniques you used. There should be a discussion of the theoretical background and implementation issues. Where applicable, talk about how the time needed to run your programs scales with the "size" of your system.
- Your results, discussion, and conclusions.

If you choose Option 2 (Programming), you can use any programming language you are familiar with and built-in functions in the math programs. You may not use codes that you have written for other courses, research projects, or extracurricular teams.