Project for M417, (Geometric and) Topological Data Analysis – Spring 2026

Overview:

1. In this project (which constitutes 70% of the grade in this course), you are asked to illustrate an application of topology/geometry/TDA. Once you choose your topic, you have to understand the way mathematical techniques are used in that particular application, provide sample calculations (and/or codes) to demonstrate the techniques, write a report on the project, and give two short presentations (one towards the beginning and one final) to the class.
2. Some very rough guidelines are given on the course webpage to help you start thinking about the project. More details will be provided for each project during in-class discussions.
3. Though the basic idea of the project is provided, you have flexibility in choosing the exact problem and solution / partial solution that you propose.
4. You can work in teams of 1-2 students, but if you prefer to work alone - that is fine.
5. During your initial presentation (10-15 minutes), you / your team will outline the area you have chosen, and the way topology/geometry/TDA is used in this application, and what is the brief goal of the project.
6. The final presentation (20-25 minutes) will summarize in more detail what you /your team have done in the entire project.
7. The rough structure of the project report to be submitted is given on the next page. (The in-class final presentation should also follow the same rough structure)

Suggestions for successfully completing a project and writing a good report:

- Read the brief project topic description given in our webpage, and any references provided there – to understand the problem.
- Read up on this topic from external sources, to get a deeper understanding of the problem. Keep a record of the sources you find useful (for citing as references)
- Discuss the problem in class discussions (both with me and with fellow students) – to get questions and suggestions from the class.
- Work out some examples by hand / by writing codes in any language you are comfortable with
- When you think you have a good idea of the problem and the proposed solutions, completely work out the main calculations (or program outputs) and start writing the report
- Feel free to include ideas / details from other sources, provided you write it in your own words and provided you cite the reference at the appropriate place. If you use (parts of) codes from other sources, if is your responsibility to fully understand the code and explain it to me.
- Do not use AI in preparing your project presentation or writing your project report. Please familiarize yourself with the academic integrity policy and policy on AI on the syllabus.

Grading Scheme (70 points):

- (15 points) The motivation of the project and mathematical details have been understood, assimilated and written in a way that is understandable to peers.
- (15 points) Correct mathematical details have been given in calculating examples and / or correct logic in the codes.
- (15 points) Independent thinking is evident in researching the material and in choosing interesting examples to include in your report. (You are free to include material from other sources, provided you write it up in your own words and cite references – books, journals or web sources)
- (10 points) Initial in-class presentation that is clear, informative and well presented (15-20 mins)
- (15 points) Final in-class presentation that is clear, informative and well presented (20-25 mins)

Project Report:

To be submitted as a pdf file (to make a professional looking report, I suggest using Latex to typeset your report – to ensure that mathematical details typeset nicely):

1. **Background:** This should be mostly motivational and should be written so that the particular application can be understood and appreciated by people without much technical knowledge of topology/geometry/TDA.
2. **Mathematical Background:** This section should be written in such a way that is understandable by a student who has completed this course. You should give all necessary mathematical details but should also explain without being too technical what the mathematical machinery is achieving.
3. **Results/Calculations:** This part should explain – through examples – the mathematics behind the application.
4. **Codes:** If your project involves programming, please include an electronic copy of the program files and sample outputs to illustrate the code.
5. **Conclusions:** Briefly summarize what you did in the project and suggest possible future work.
6. **List of References:** Include the sources you have used to complete the project and to write the report, including books, journal articles and webpages / videos.

<u>Below is a sample for citing references</u> (source: https://guides.tricolib.brynmawr.edu/c.php?g=285071&p=1899518)

References (list at END of paper, with citations alphabetical by AUTHOR):

Journal Article (one author):

[3] S. Dostoglou, S.: On the asymptotics of the finite energy solutions of the Yang-Mills-Higgs equations, *Journal of Mathematical Physics*, **31**, 2490-2496 (1990).

Journal Article (multiple authors):

[2] S. Carstensen, E.P. Stephan, Adaptive boundary-element methods for transmissions problems, J*ournal of Mathematical Analysis and Applications*, **106**, 367-413 (1985).

Book (one author):

[1] C.P. Bruter, *Mathematics and Art,* Springer, Paris, 2002.

Book (multiple authors):

[4] N. Lesmoir-Gordon, M, Frame, B. Mandelbrot, N. Neger, *Mandelbrot's World of Fractals*, Key Curriculum Press, 2005.

Web Page:

[5] G.P. Michon. Final answers: Perimeter of an ellipse http://numericana.com/answer/ellipse.htm (updated May 17, 2011)