MATH 312: LINEAR ALGEBRA PROJECT: SUMMER II 2019

Contents

Project can either be done individually or in pairs.

The point of this project is to learn on your own a small topic in linear algebra, or apply some technique from inside or outside the course to a novel application, and write up a brief (2-10 page) explanation of it in your own words (the final report). Reading and writing maths is hard and not usually well covered in maths courses – I'm hoping that this can serve as an introduction to this. If you're having a lot of difficulty understanding any of the sources you look at, then bring the sources you are using and specific points of confusion into the progress meeting.

A list of possible topics, with references is included in this document. You are encouraged to choose a project not on the list if that is what you are most interested in – however I need to approve it, and can do so if you tell me the topic and at least one reference on it that you plan to use. For the more applied projects it is important that your report still makes the mathematical content of your work clear.

1. Timeline

- Friday 12th July: Project topic must be finalized. You must have emailed me with your project topic. If it is not one of the project suggestions here I must have approved it.
- At latest Friday 26th July. You must have discussed progress with me. I will set up time slots for this during the preceding week.
- Tuesday 30th July; Draft submitted, will be returned with comments by Thursday 1st August.
- Friday 8th August 5PM; Final Report submitted.

2. Project Suggestions

- Projective Geometry, perspective, computer graphics. Given a three dimensional landscape/computer model, when we view it we see a two dimensional image. How do we (or say a computer renderer) produce a two dimensional image from a three dimensional image. What are 2 dimensional phenomena such as the Horizon line?, where do parallel lines (in the 3 dimensional world) "meet" (in the two dimensional "view")? Recommended references: Chapters 2 and 3 of Richter–Gebert's "Perspectives on Projective Geometry," draft available at `https://www-m10.ma.tum.de/foswiki/pub/Lehre/WS0910/ProjektiveGeometrieWS0910/GeomBook.pdf`. See also Davis' "Homogeneous Coordinates and Computer Graphics" `http://www.geometer.org/mathcircles/cghomogen.pdf`.
- Image Compression. There are many methods for image compression, describe one of these. We are going to briefly mention singular value decomposition in the course. In particular the wikipedia pages on Discrete Fourier Transform, and/or Fast Fourier Transform give a starting point, as do the Heckbert's notes `http://www.cs.cmu.edu/afs/andrew/scs/cs/15-463/2001/pub/www/notes/fourier/fourier.pdf`.
- Game Theory and/or Linear Programming. There is a chapter on this in Gilbert Strang's "Linear Algebra and Applications."

- Data Fitting. In the course we are going to cover some least squares minimization. Apply this (or some other approach to data fitting) to some set of real world data (NB: You need approval from me for the phenomena that you will be modelling, and it needs to be more involved than doing one least squares minimization).
- Machine Learning (Various) – precise topic/application would need approval from me. Either explain the linear algebra involved in some machine learning method, or implement a toy case thereof.
- Hamming Code. An error correcting code.
- Curve fitting with Splines. A place to start is Donald House's notes `https://people.cs.clemson.edu/~dhouse/courses/405/notes/splines.pdf`. Another introduction is Jingmei Qiu's notes `https://www.math.uh.edu/~jingqiu/math4364/spline.pdf`.
- Numerical Stability/Instability of Linear Algebra Techniques. The simplest example of considering this is the condition number, see e.g. Cleve Moler's blog post `https://blogs.mathworks.com/cleve/2017/07/17/what-is-the-condition-number-of-a-matrix/`, though I would want a project to do slightly more than this. I would recommend picking one topic in Rannacher's lecture notes `https://ganymed.math.uni-heidelberg.de/~lehre/notes/numla/NumLinAlg.pdf`, and/or doing some calculations of error with various concrete matrices.