MAE 290A Numerical Linear Algebra

Final Project Description

Note: *You may work individually or in pairs. Outside your group, you may discuss the project in a general way among yourselves, but you may not use other students' written work or programs. Use of external references for your work should be cited. Please also report in your acknowledgements, other students, outside your group (if any), you discussed with during your completion of the project.*

In the final project, you will explore performance of Krylov subspace methods in a computational study. We studied GMRES (T&B L35) for non- symmetric linear systems, but there are cost issues associated with it that are avoided by other methods. Some of these alternatives are the BCG (T&B L39, Dec. 2 class lecture), Bi-CGSTAB (stabilized BCG), CGS (conjugate gradients squared) as well as QMR (quasi-minimal residuals). Examine the literature on this topic, implement three of these methods (GMRES vs BCG vs a third method of your choice from the list: CGS, Bi-CGSTAB, QMR and compare their performance on some benchmark problems. Your project should consist of the following components:

- Small GMRES literature search
- Conduct numerical experiments using traditional GMRES, BCG and an alternative method listed above. (Numerical method code must be your own; you may consider different parameter spaces or examples).
- Analyze the results
- Summarize findings in a scientific report

You may use the matrix market repository to create your benchmark problems or problems from your own research.

Final Report – December 12th – PDF uploaded to Canvas

The report will take the form of a scientific article, including

- **Introduction** of the problem of interest. Provide necessary background and context, setup the problem to be studied in depth including choice of application.
- **Numerical methods** involved with reference to code which you've written.
- **Discussion/Analysis** of your results. Discuss some aspects of the topic, using your data as evidence or to illustrate key points. Your discussion should connect back to the theory
- **Conclusions** of how the methods compare.
- **References**. Please cite at least 5 relevant papers from the literature in your write-up and discuss how they are related to methods and/or application.
- **Contributions** of each author if you are more than one.
- **Appendix** containing your code. You may need to include a description of the algorithm or snippets, but only do so if these are discussed in the text.

Try to make plots and tables clear and concise, and make sure to include captions.

Common numerical analysis topics to address are:

- What mathematical aspects of the problem create challenges for numerical methods? How are these issues addressed ? (This is usually the fundamental question to ask.)
- How does the error behave (rate, order of convergence; how long does it take before the error settles down into a predictable pattern) ?
- What are the trade-offs involved in designing the method, e.g. efficiency vs. robustness and so on? How can the methods be made efficient/accurate (or other desirable properties) ?
- What mathematics is involved in the derivation and analysis of the method (typically error analysis and stability) ?