AMSC/CMSC460 Computational Methods **Spring 2015**

Group Projects

1. *(Iterative methods for linear sparse system)*
The goal is to efficiently solve linear system $Ax = b$. Methods like Gauss elimination is costly for large system, especially when A is sparse. The idea of the iterative methods is to construct low-cost iterative procedures and solve x as the limit of the iteration procedure. Typical methods including Jacobi method, Gauss-Seidel method and Successive Overrelaxation (SOR) method. We shall investigate these methods with error analysis, Matlab implementation and numerical experiments.

2. *(Eigen-system for large matrices)*
Finding eigenvalues and eigenvectors for a large matrix A has lots of real world applications (e.g. Google search). There are many efficient methods which are used to find eigenpairs of a matrix. One widely used method is called power method, which is very efficient to find the largest eigenvalue and its corresponding eigenvector. Jacob method, QR method (and many more) are used to solve the complete eigen-system. We shall investigate some of these algorithms, understand when and how does the algorithm work, and perform some experiments in Matlab.

3. *(Polynomial approximation: minimizing infinity-norm)*
In the polynomial interpolation theory, there is a Runge phenomenon which states the fact that high order interpolation might suffer large pointwise error. The goal of this project is to find a polynomial which best approximate a function pointwisely. The best polynomial is the interpolating polynomial with respect to Chebyshev nodes. We will study the properties of Chebyshev nodes and the reason reason why such nodes work the best. We should also perform some Matlab experiments to test the performance.

4. *(Extrapolation in numerical integration)*
For composite Newton-Cotes type integration methods (and actually for many other methods as well), an important question is, how fast does error go to zero as the cell size h becomes smaller. For instance, the composite trapezoid rule has the convergence rate $\mathcal{O}(h^2)$. Extrapolation methods are intended to increase the rate so that the scheme will have a faster convergence. We shall investigate the Euler-Maclaurin formula, and understand how the extrapolation works. Also, we should produce some numerical experiments to verify the faster convergence rate.

5. *(Numerical methods for boundary value problems of second order ODE)*
The goal is to solve a second order ODE equiped with boundary conditions. We shall study the easiest setup and try to solve the prblem using several methods, including shooting method, finite difference method, etc. We will compare the numerical solution with the exact solution and verify the performance of each method.