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Research Summary

Essentially Non-oscillatory schemes are a relatively new tool for computing numerical approximations to conservative partial differential equations. While at Brown University, I was able to study under Chi-Wang Shu, one of the inventors of ENO schemes. ENO schemes virtually eliminate numerical oscillations, yet they are computationally expensive schemes.

The problem of computational speed for ENO schemes arises from the need to evaluate several *if–then* statements for each grid point in the data. My Ph.D. thesis presented an adaptive grid algorithm for use with ENO schemes, and my most recent paper, "A Hybrid Adaptive ENO Scheme," presented an adaptive semi-conservative ENO scheme. Both methods reduced *cpu* time to a fraction of the *cpu* time required for a normal ENO computation by continually finding the *optimal* non-uniform computational grid.

The major improvement between the two methods is that the most recent method can be economically expanded into higher dimensions. This expansion into higher dimensions is the important next step in the development of this algorithm. It will lead to an efficient algorithm for the solution of typical conservative convex hyperbolic equations such as Euler's gas equations and combustion models and atypical non-convex problems as well.

In a more mainstream direction, I have considered the problem of recovering exponential accuracy from the Fourier coefficients of a non-continuous function. The difficulties inherent in this problem are the well known Gibbs phenomenon oscillations present in any truncated approximation to a non-continuous function. This project was solved in two steps. The first step is computing a highly accurate approximation to location of the function discontinuities. My research found a family of spectral filters which when applied sequentially provided a high order approximation to the shock location. The first few filters are either high or band pass filters which remove everything except the Gibbs oscillations around each shock location. The final filter cuts through much of the *noise* to provide the final estimate.

The second step converts the truncated Fourier expansion into an expansion in terms of Gegenbauer Polynomials $C_n^\lambda(x)$. This part of the problem was already resolved by Gottlieb, Shu, Solomonoff and Vandeven for the case when the shock locations where known. Combined with my family of spectral filters, the solution is complete.

Recently, while living in Los Angeles, I have developed an interest in the study of traffic. The wave-like features which permeate through the traffic flow and the sharp change in car density are a couple beautiful computational obstacles. Presently many attempts to model traffic flow have used models similar to fluid dynamic models. Unfortunately these models have some un-realistic behaviors including backwards flow and vehicle speed influenced by the cars behind. Since there are a relatively small number of vehicles to model, an atomistic model of traffic will be better suited for this problem. This idea is similar to the Nagel and Schereckenberg's model using Cellular Automata. The model which I am developing allows each driver to have a slightly different (randomly determined) driving personality. This will help to model the random movements executed by drivers. The resulting stochastic model will enable a detailed analysis of freeway traffic. Early tests have produced results which seem to be verified by test data received from road sensors. The next step will be the expansion of this model to multiple lanes.