Ay190 – Worksheet 16
Anthony Alvarez
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1 Finite Volume Shock

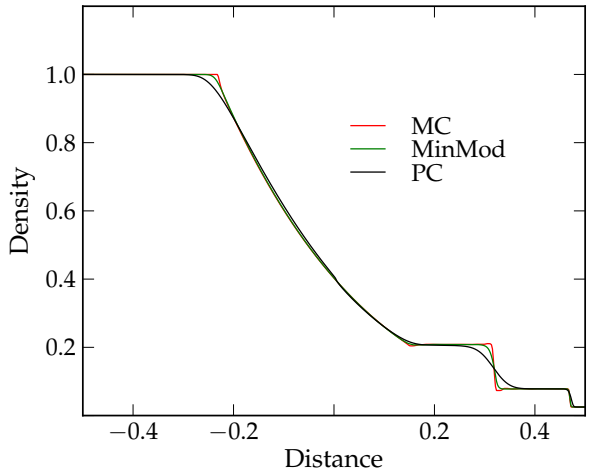
We implement a Finite Volume Code for a Shock Tube with the following parameters on a domain of $[-0.5, 0.5]$ with $r = 0$, $\rho_L = 1.0$, $\epsilon_L = 2.5$, $v_L = 0$, and on the right side $\rho_R = 0.25$, $\epsilon_R = 1.795$, $v_R = 0$ and the adiabatic exponent of $\gamma = 1.4$.

1.1 Commpare Methods

We implement the code in python and run it to a final time of $t = 0.2$.

For the various methods (piecewise constant, TVD-midmod, and TVDMC2) we record the amount of time it takes to compute 0.2 seconds worth of simulation. We get 38.21 , 50.53, 63.93, seconds for the three methods respectively, with out any graphing.

At the final time of $t = 0.2$ we can see in 1 that the shock has completely devloped but is missing features near the initial discontiuity. The rarefraction has compeletly eclipsed the nearest density plateau.



Finite Volume.pdf

Figure 1: Graph of density with respect to space on the domain $[-0.5, 0.5]$. At time $t = 0.2$ for three different methods.

1.2 Compare to SPH and Exact Solution

The Finite Volume Hydro code we've implemented seems to differ greatly from the exact solution. The finite volume codes have expanded the rarefraction and completely obliterated the first plateau at roughly $x = 0$, while the SPH sill maintains this feature. 2 Note that we have the same number of grid points as particles, $n = 500$.

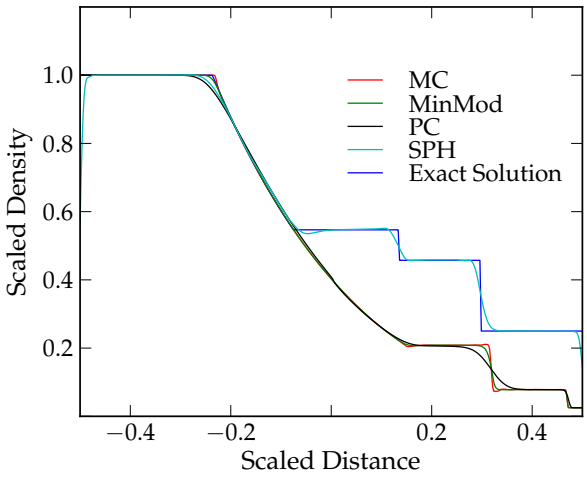


Figure 2: Graph of density with respect to space on the domain $[-0.5, 0.5]$. At time $t = 0.2$ for three different methods.

1.3 Code Improvements

Our finite volume code initially used slow for loops making the code take upwards of a minute to simulate to $t = 0.2$. By leveraging numpy array operations we are greatly able to reduce the runtime. For the methods piecewise constant, TVD-midmod, and TVD-MC2 we are able to get computation times of 4.08, 7.07, 7.86 seconds without any graphing. We get a 9 times speed up on piecewise constant, 7 times speed up on midmod, and an 8 times speed up on mc2. This is a huge improvement from just a few changes to the code. You can see the array based implementation in hydro_1D_FV.py while the loop implementation can be found in hydro_1D_FV.py.