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Title: Investigations in Cell-Centered Hydrodynamics

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Investigations in Cell-Centered Hydrodynamics

Computational Physics Workshop

Lauren Green and Logan Thorneloe

Mentor: Marc Charest

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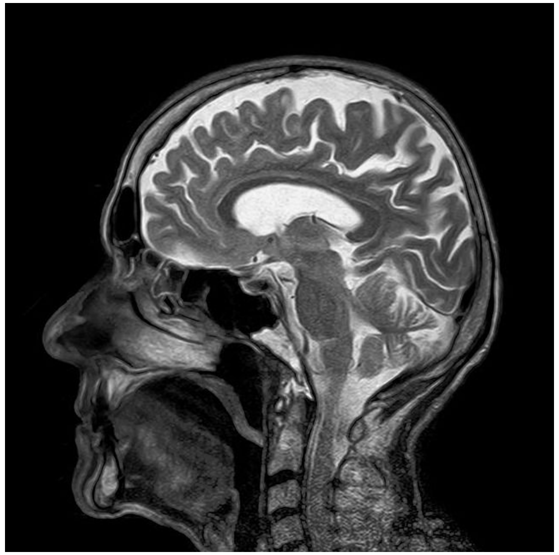
Logan Thorneloe

- Attending Brigham Young University, Provo
- Bachelor of Science, Computer Engineering
- Personal Interests: water polo, swimming, technology
- Research Interests: magnetic resonance physics, bioelectronics, machine learning, computers



Lauren Green

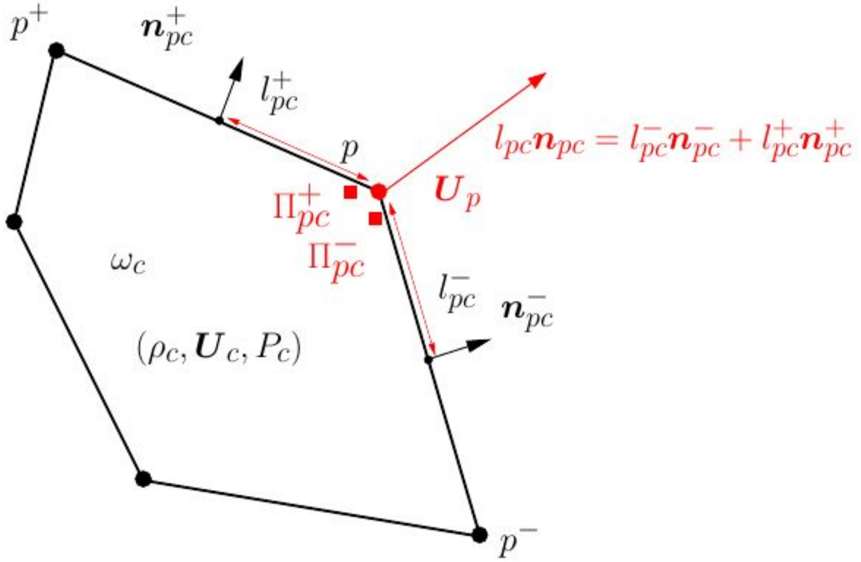
- BS in Nuclear Engineering and Radiological Sciences (NERS), Class of 2018
- starting NERS MSE this fall
- personal interests: travel, food, puppy

Comparison of CCH Lagrangian Schemes

Nodal velocity computation via sub-cell force balance:

$$U_p^n = (M_p^n)^{-1} \sum_{c\epsilon C(p)} \left[l_{pc}^n P_c(\boldsymbol{x}_p^n) \boldsymbol{n}_{pc}^n + M_{pc}^n U_c(\boldsymbol{x}_p^n) \right]$$

$$M_p^n = \sum_{c\epsilon C(p)} M_{pc}^n$$



Corner matrices corresponding to GLACE[2], EUCCLHYD[2], and Burton et al.[1] schemes

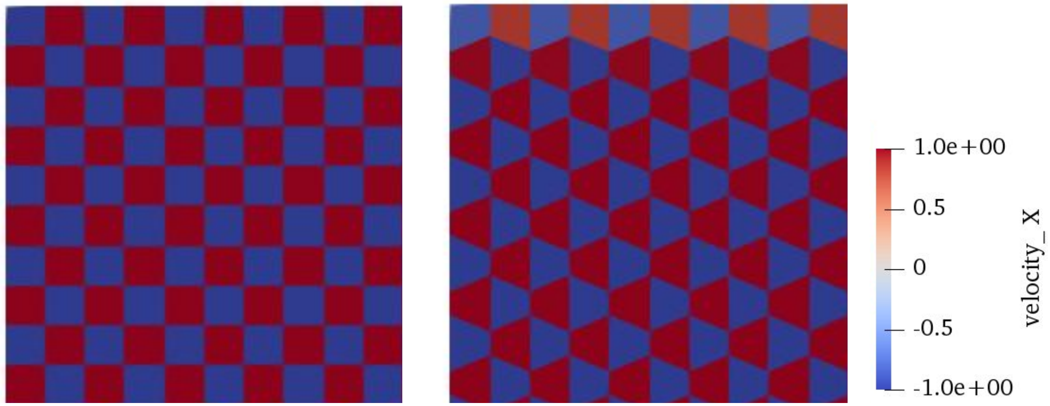
$$M_{pc}^{GLACE} = z_c l_{pc} (\boldsymbol{n}_{pc} \otimes \boldsymbol{n}_{pc})$$

$$M_{pc}^{EUCCL} = z_c [l_{pc}^- (\boldsymbol{n}_{pc}^- \otimes \boldsymbol{n}_{pc}^-) + l_{pc}^+ (\boldsymbol{n}_{pc}^+ \otimes \boldsymbol{n}_{pc}^+)]$$

$$M_{pc}^{BURT^1} = z_c l_{pc}^- |\boldsymbol{n}_{pc}^- \cdot \hat{\boldsymbol{u}}_{\boldsymbol{c}}| + z_c l_{pc}^+ |\boldsymbol{n}_{pc}^+ \cdot \hat{\boldsymbol{u}}_{\boldsymbol{c}}|$$

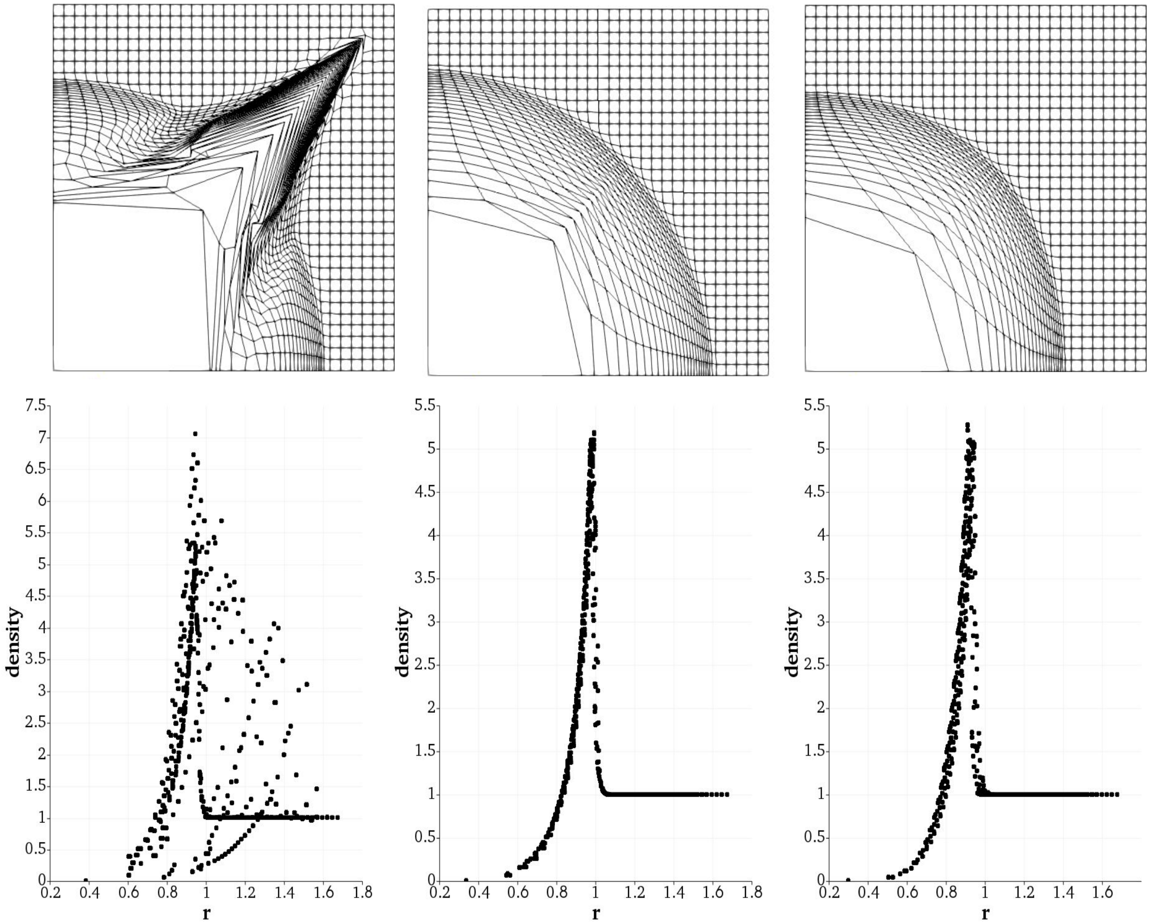
Numerical Tests in 2D Cartesian Geometry

Checkerboard Problem:



GLACE **EUCCLHYD**

Sedov Problem:



GLACE **EUCCLHYD** **BURT. et al.**

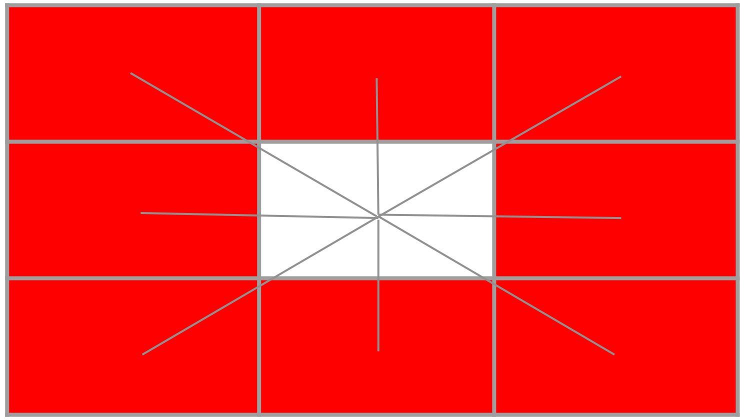
Conclusions

- GLACE scheme experiences instabilities in both checkerboard and sedov problem
- EUCCLHYD performs well in both test cases, most accurate of the three schemes
- Burton et al.'s model is more dissipative and improves mesh robustness, but smaller time step

Linear Least Squares Reconstruction

Goal: better estimate nodal velocity

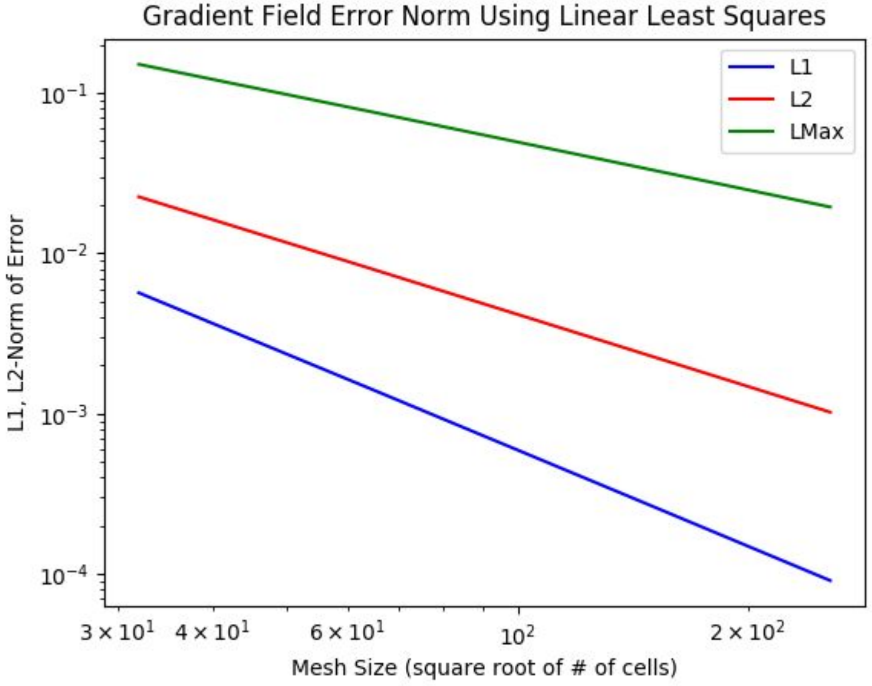
- utilizes values at centroids to construct gradient field for a single cell



- use gradient to calculate values at cell vertices

$$u = u_0 + \frac{du}{dx}(x - x_o) + \frac{du}{dy}(y - y_0)$$

As the number of cells in a mesh increases, the error of least squares function decreases



References

[1] D.E. Burton, T.C. Carney, N.R. Morgan, S.K. Sambasivan, M.J. Shashkov. A cell-centered Lagrangian Godunov-like method for solid-dynamics. *Computers and Fluids,* 2012.

[2] P.-H. Maire. Contribution to the numerical modeling of Inertial Confinement Fusion, 2011.Chapter 3, pp 57-158.

[3] Timothy J. Barton. Recent Developments in High Order K-Exact Reconstruction of Unstructured Meshes. *31st Aerospace Sciences Meeting & Exhibit*, 1993.