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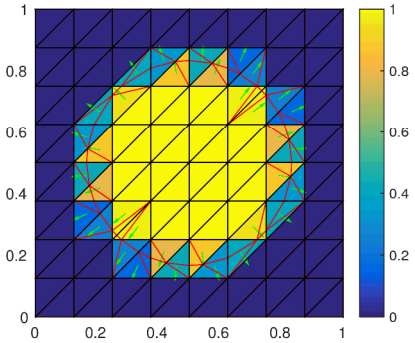

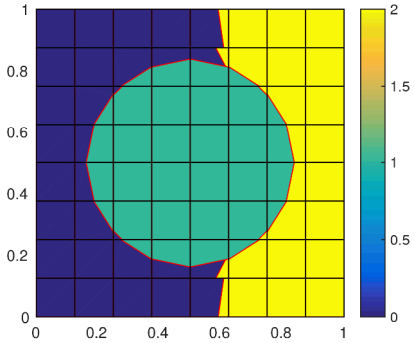

Investigating level set methods for interface reconstruction

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U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

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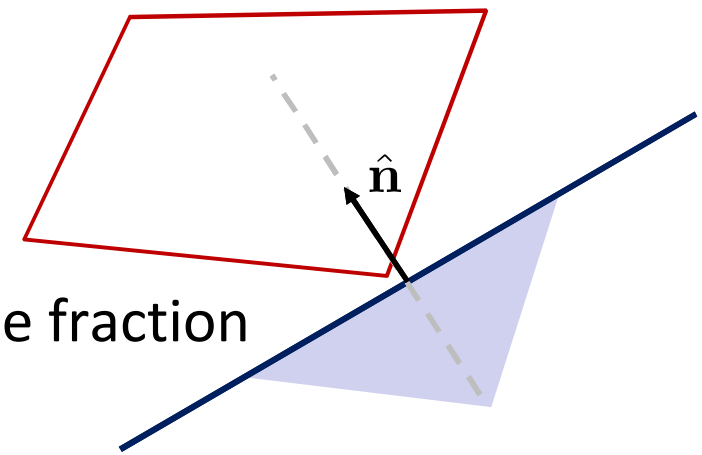
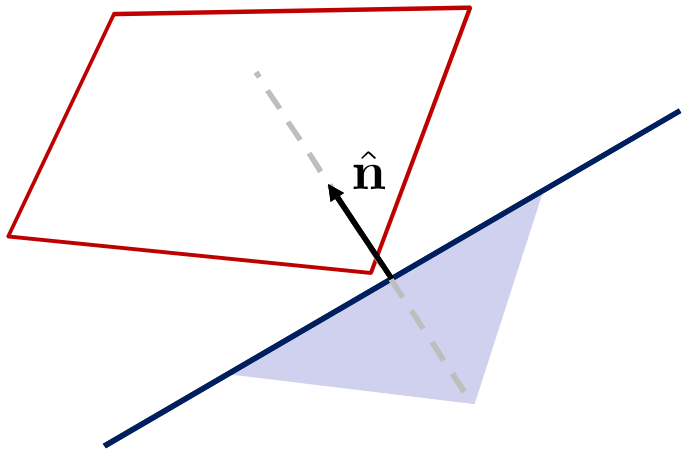
Interface Reconstruction

- Investigate level set approx of volume-of-fluid (PIR) interfaces
  - The initial interface was made by a single cut
  - From this single cut we have 1 material + void for each element
  - We then use the Dukowicz
  - algorithm to calculate the normal
  - for each cut element
  - From this we find the optimal
  - position for the normal plane
  - in order to cut off the proper volume fraction



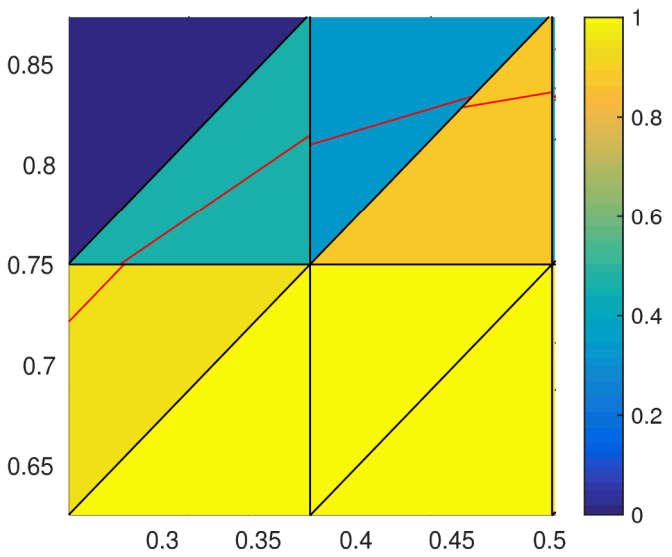
Interface Reconstruction

- Investigate level set approximations of volume-of-fluid (PIR) interfaces
  - Looping over each element we use an L-2 projection to get a nodal cut field
  - Then we make cuts according to these distances which gives us our level-set approx.

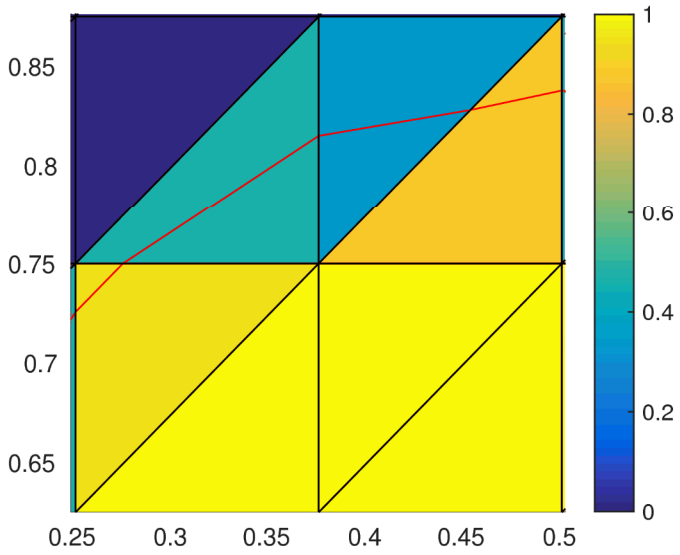


Single Material Interface

Volume-of-Fluid



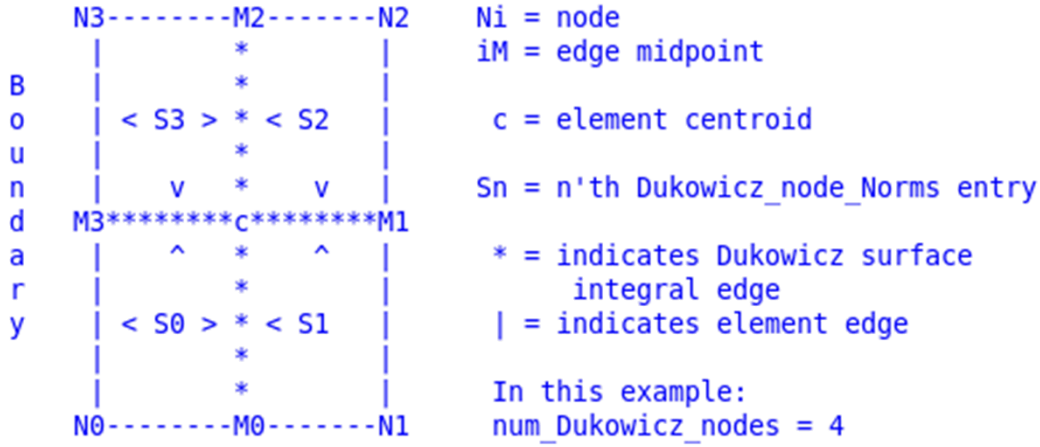
Level-Set



In VoF we see jagged edges because we have conservation of mass, but we do not in our Level-Set approximation

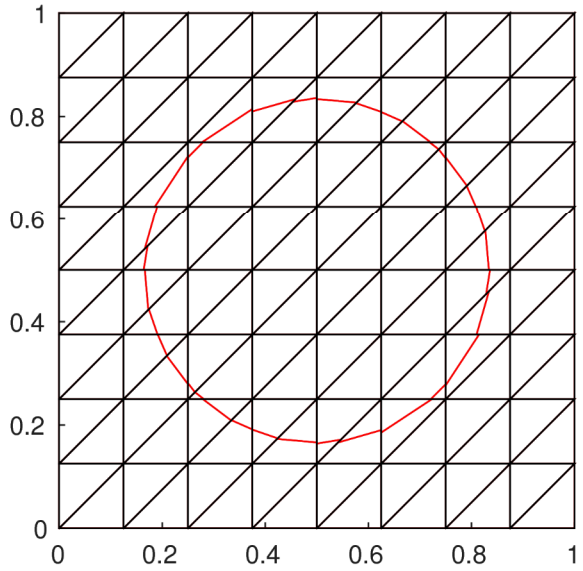
Dukowicz Algorithm

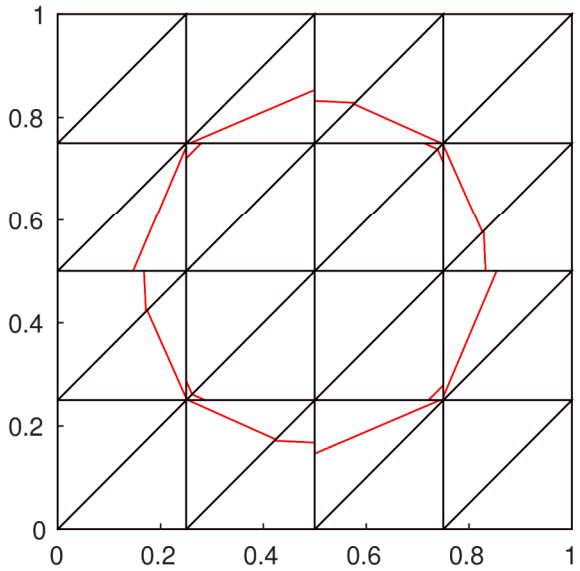
- Loop over all elements to obtain contributions



- Loop over Mixed Elements to calculate gradient of the volume fraction from nodal contributions and from this we are able to calculate the normals.

Volume-of-Fluid Reconstruction





With a circular cut we end up using a linear level set approximation for the cut, so for the volume fraction we can get an exact volume fraction or the approximation.

Level Set Approximations

- Smallest distance from node to normal of volume-of-fluid cut.
  - Loop over all nodes to get distance from node to each cut
  - We get a distance using the Hessian normal form

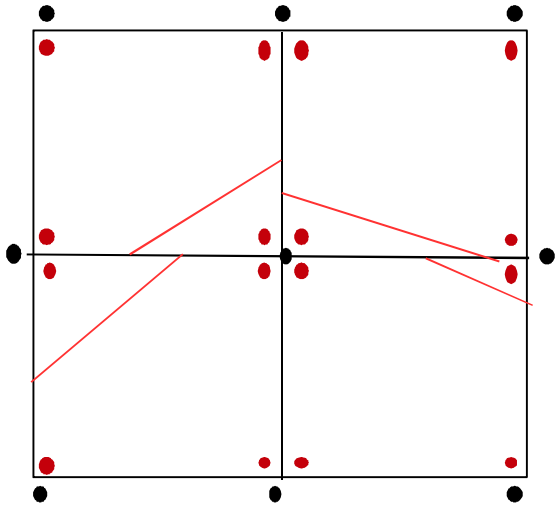
$$D = n \cdot x_0 + p$$

where n is the normal, x is the point of the node and p is the distance of the plane from the origin

  - From these distances we keep the smallest one and use it as our node to cut distance as an approximation for a level set.

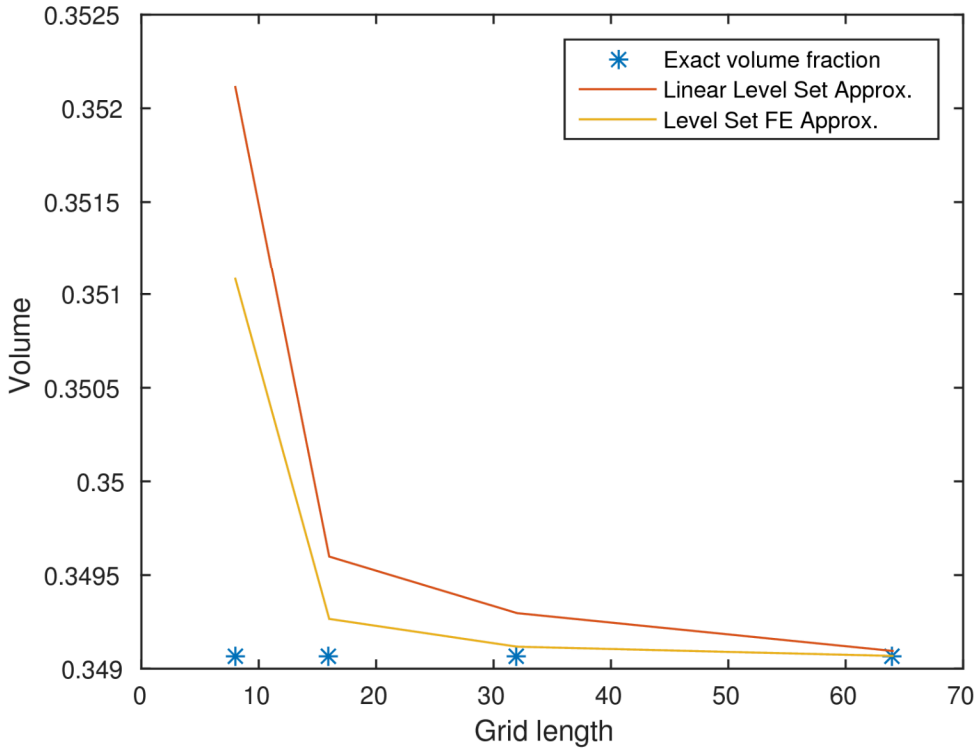
Level Set Approximations

- L-2 projection calculation of contributions from each element for cut to node distance.
  - Loop over cut elements and create nodal cut field corresponding to that element.
  - Loop over cut elements again, but with the L-2 projection we get an approximation for each node from each elements contribution to the nodal field from the cut to approximate a level set.

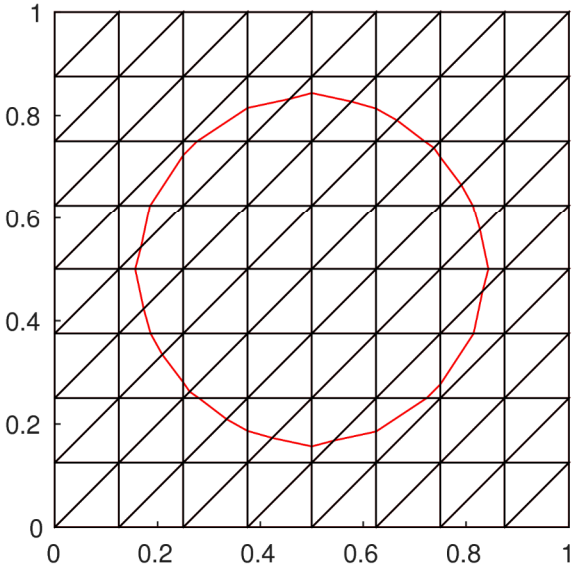


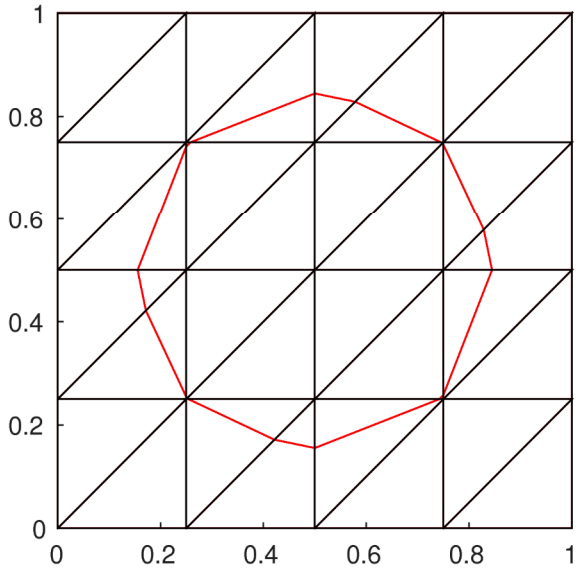
Level Set Approximations

- The L-2 projection we use gives a better approximation and we see this from the volume fractions that can be calculated of these approximations.

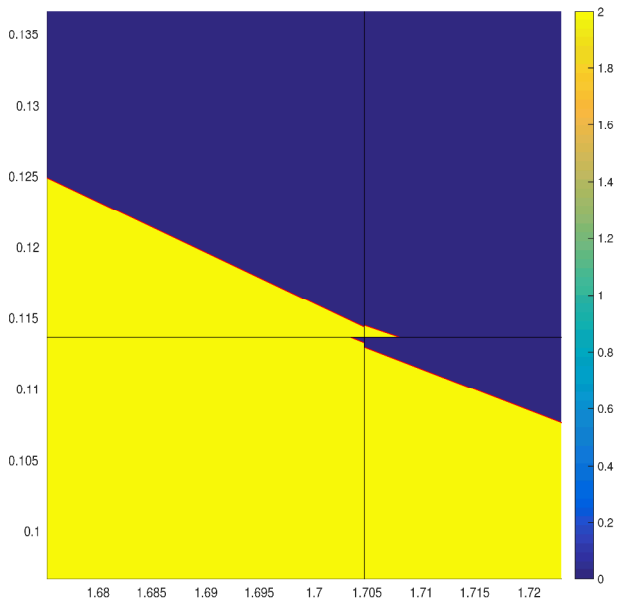


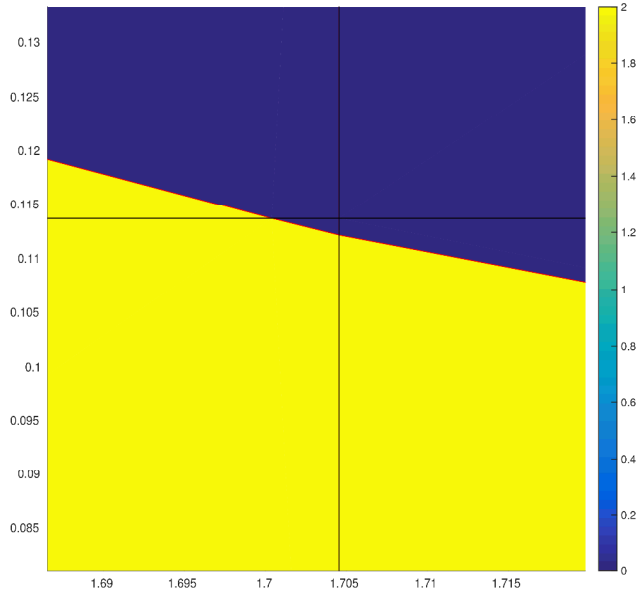
Level-Set Reconstruction





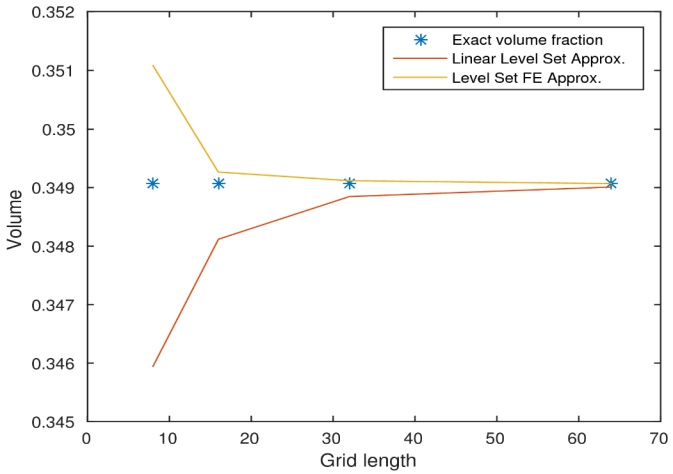
Level-Set Reconstruction

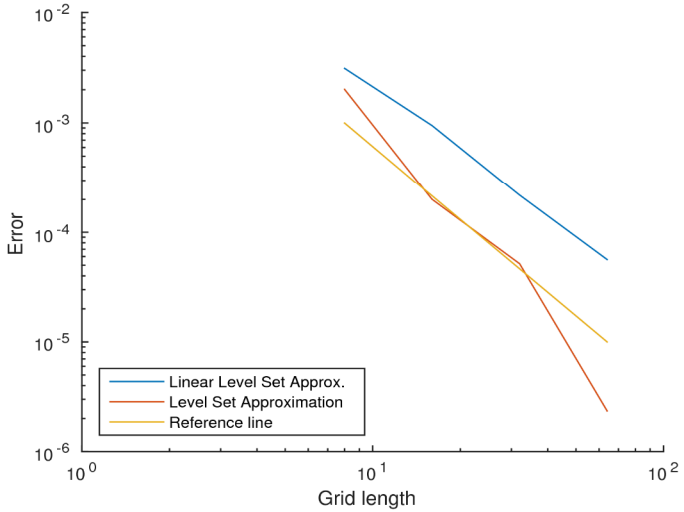




- An interesting find from our level-set reconstruction is that when an element has a small volume fraction then in our level set reconstruction it is completely taken out.

Error of Reconstructions for a Single Material



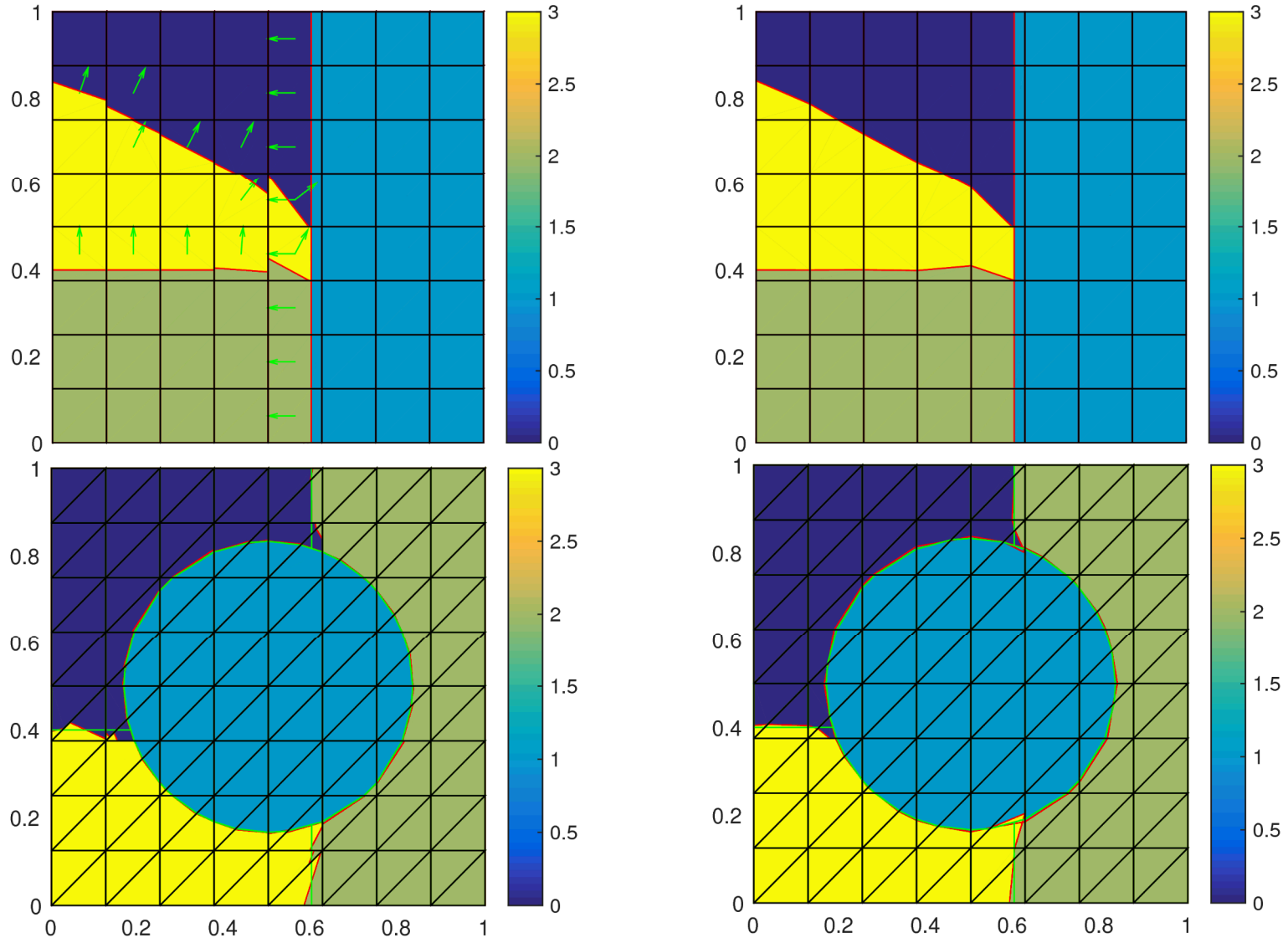


- We can find the volume fraction for each element of the level-set approximation in order to compare it with that of the volume-of-fluid

Extending to Multiple Materials

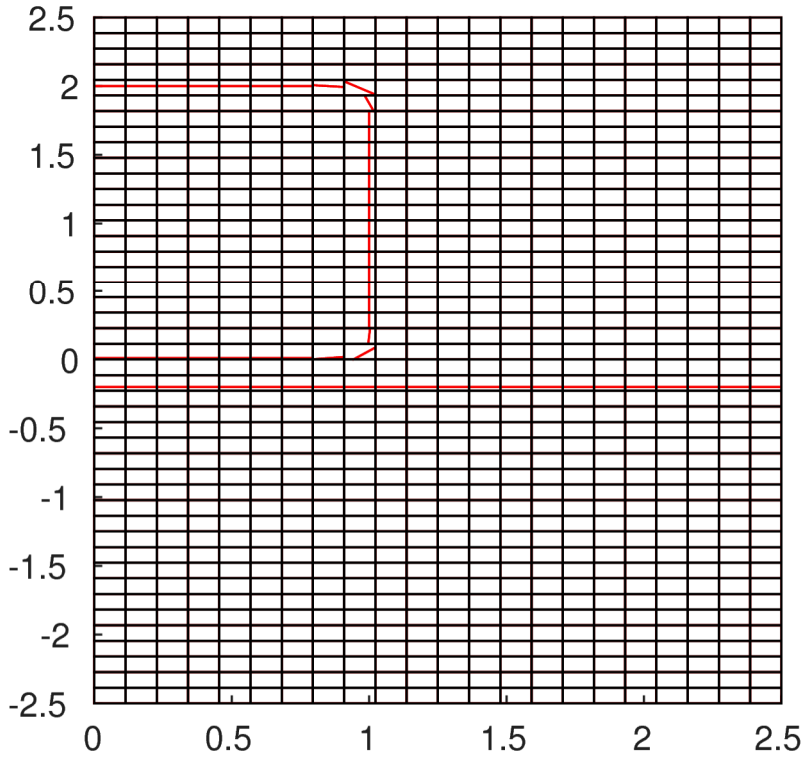
- Having been able to recreate an approximation for a level set interface for a single material we extend this to multiple materials
- The same process occurs but now for each cut, so if an element is already cut with material in it, the next cut then doesn't change that, but cuts in the remaining void material.

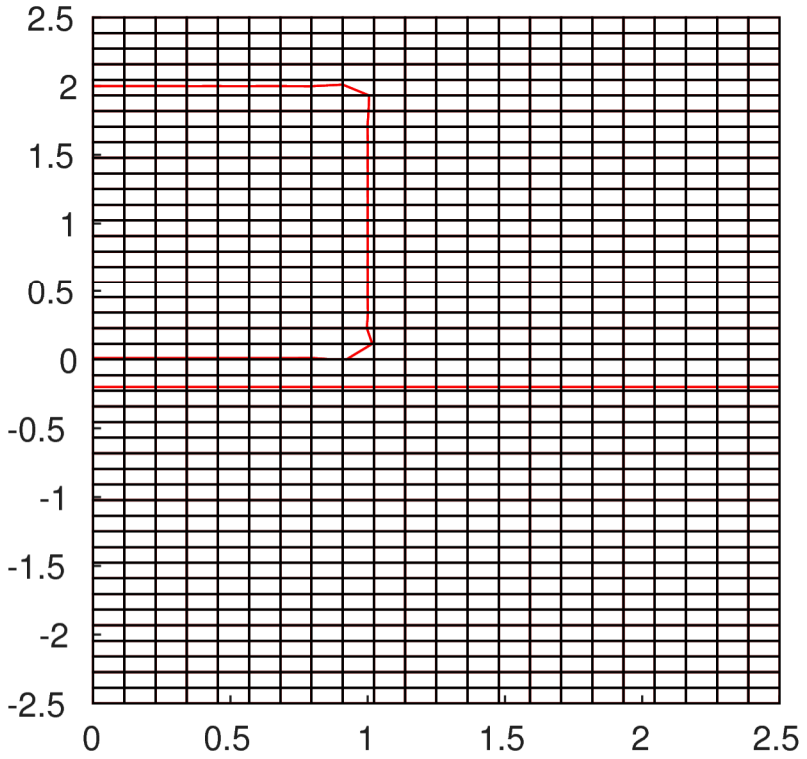
Extending to Multiple Materials



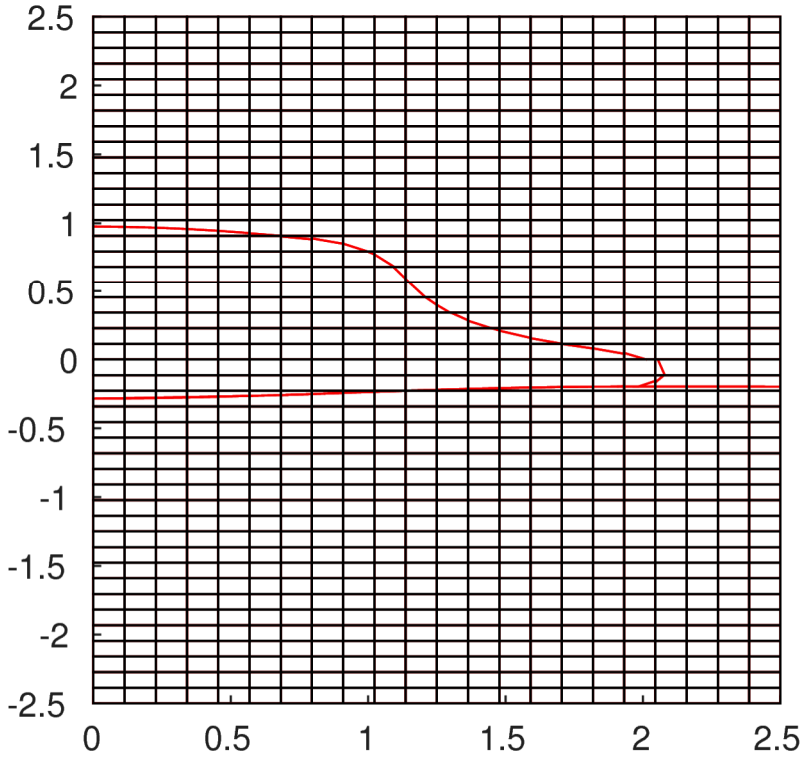
Examples from Alegra

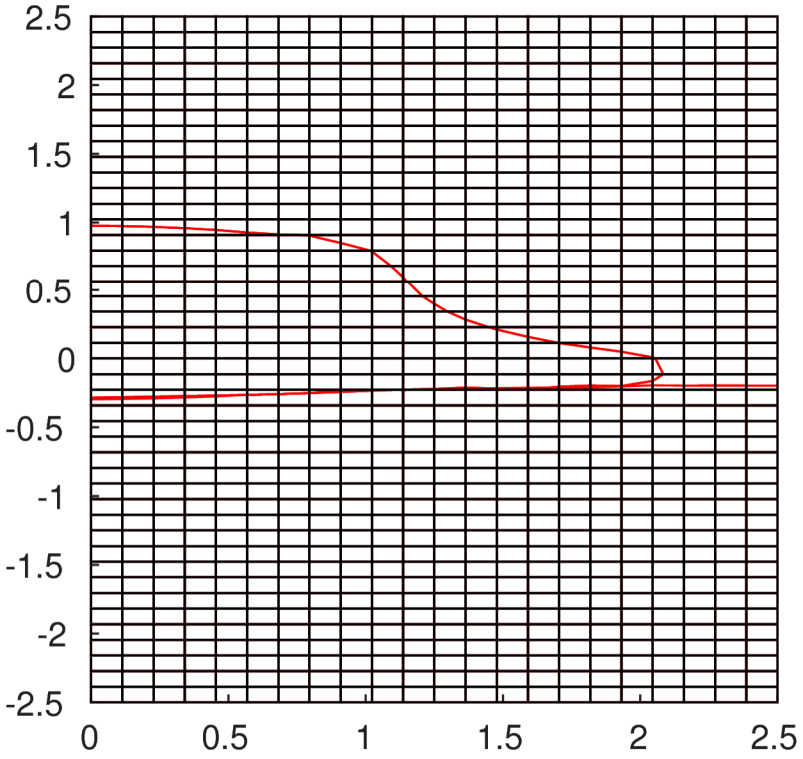
- Now that we have recreated level sets in our example Matlab code we wanted to try with some example output from Alegra



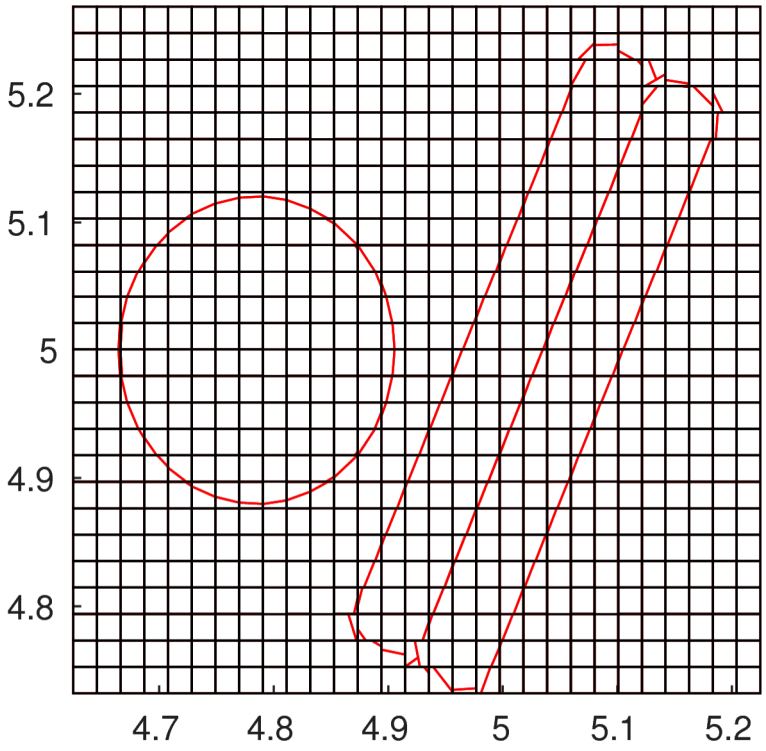


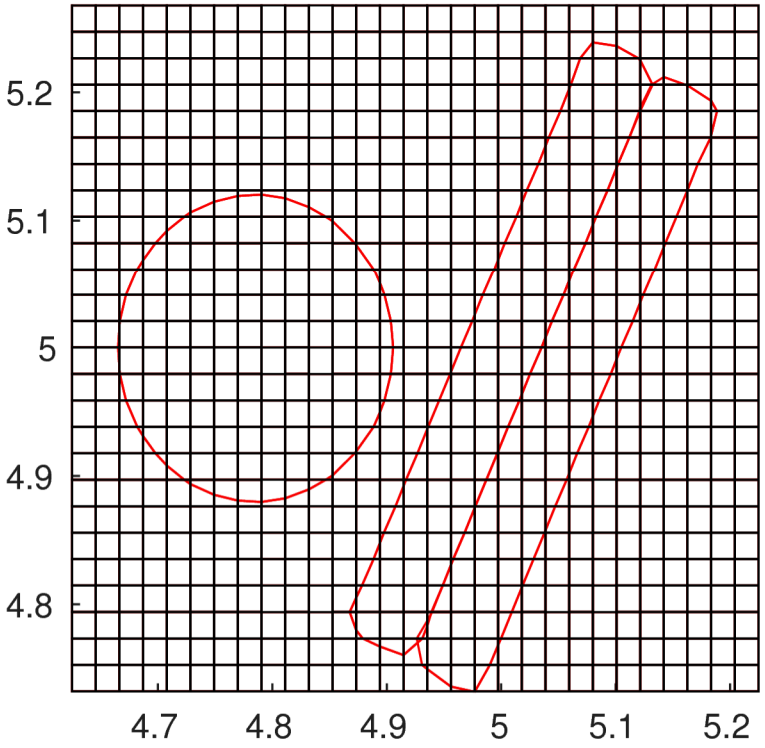
Examples from Alegra





Examples from Alegra





Examples from Alegra