ACCURATE COMPUTATION OF CURVATURE IN LEVEL SET METHOD

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INTRODUCTION

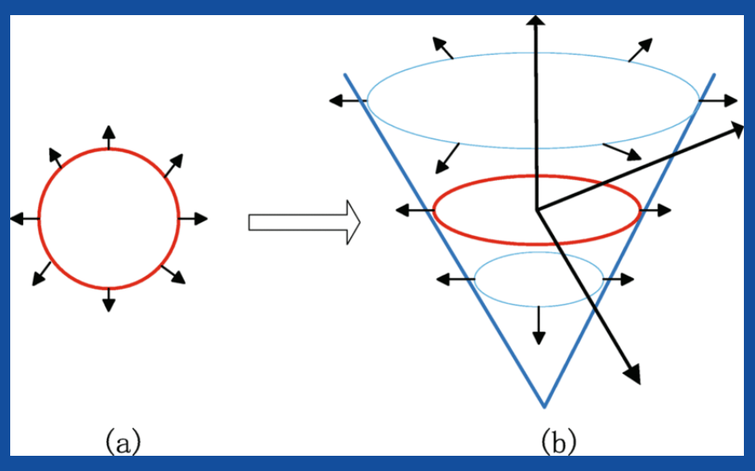
Numerical simulation is an engineering tool that is widely used to describe many phenomena in the fluids mechanic's field.
The main objective of my internship was to calculate the curvature between two non-miscible liquids using numerical simulation. To do that it was necessary to add an extra term to the Navier-Stokes equation that describes the value of the interface between both liquids.

$$\rho\left[\frac{\partial \bar{u}}{\partial t} + (\bar{u}\cdot\bar{\nabla})\bar{u}\right] = -\bar{\nabla}P + \rho\bar{g} + \eta\Delta\bar{u} + \sigma k\bar{n}\delta_{\Gamma}$$

METHODOLOGY

By using the Level set method, we define a G(x,y,z) function representing the distance of the point (x,y,z) to the closest portion of the interface between the two phases, the method tracks the movement and deformation of the interface over time.

The level set function assigns positive or negative values to points in space, with the interface represented by the zero level. This technique allows us to easily identify the shape of our interface and subsequently calculate its curvature.



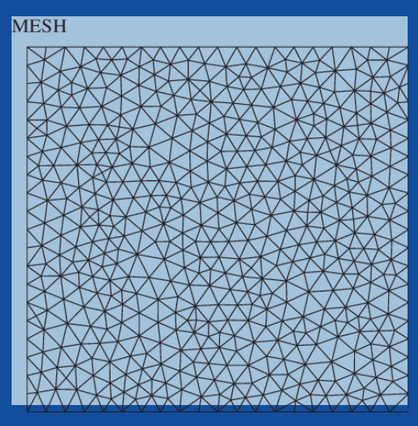
RESULTS

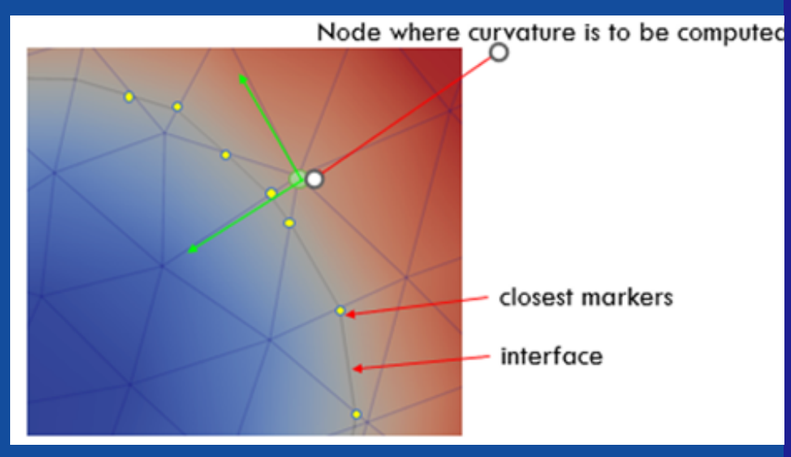
The method of averaging the values of curvature of the points is not always a good way to obtain the curvature value when the shape changes, because the averaging points will not always be near enough.

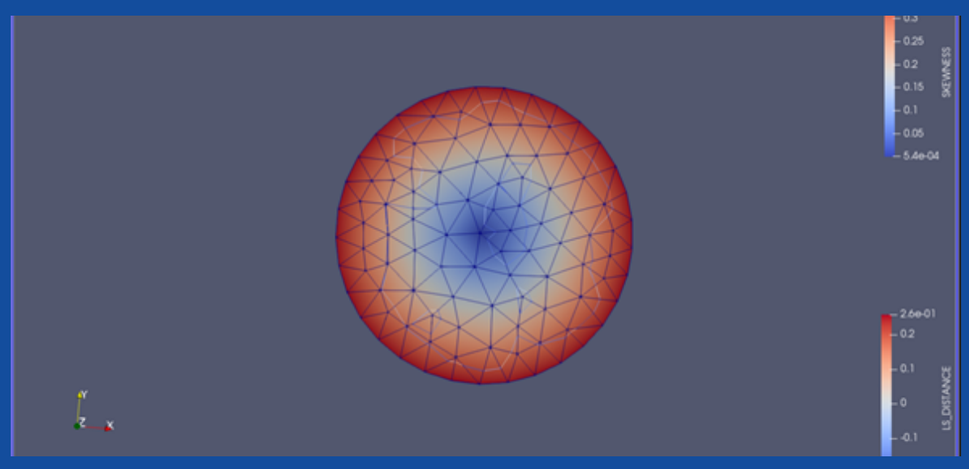
So to address this issue we have decided to apply a different approach using the level set method as starting point.

We decided to use the calculation of the interface to locate it in space, once we have done this we are going to calculate the curvature by trying to fit a parabola troughtout all the points that are part of the interface.

By doing this we must obtain a better outcome of the curvature's value, but apparently after some tries we have noticed that when we create a finner mesh the error is turning into a constant value.







CONCLUSION

Our findings revealed that the modified level set method offered improved accuracy compared to the original implementation, particularly when using a coarse mesh. However, as we refined the mesh to make it finer, we encountered a lack of convergence in the error.
That is why we decided to change the approach we were using to calculate the curvature. We implemented the parabolic fit method

References

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- A massively parallel accurate conservative level set algorithm for simulating turbulent atomization on adaptive unstructured grids, Elsevier, 2022.