REMESHED SMOOTHED PARTICLE HYDRODYNAMICS PLATFORM.

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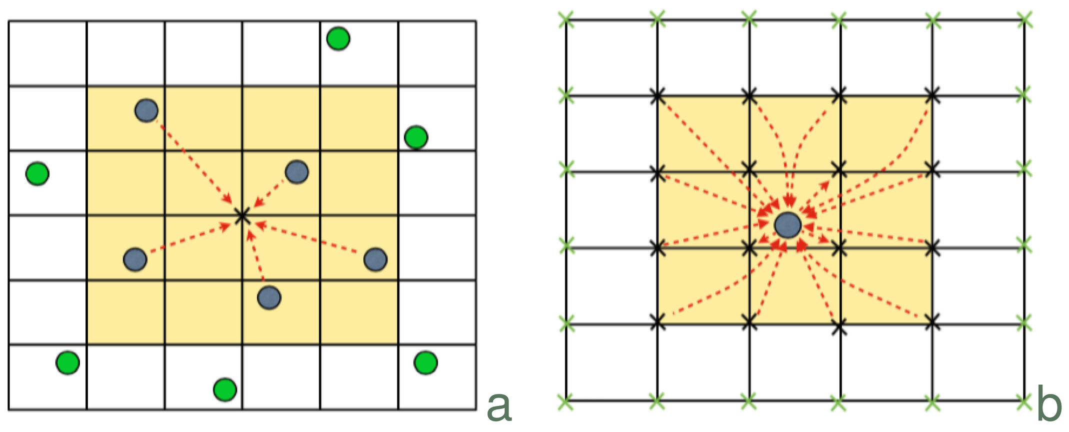
DISCRETE MATERIALS

A 3-D hybrid smooth particle method (hrSPH) /citeobeidat is used to model the three dimensional viscous flow. The method offers a highly efficient particle-mesh and particle-particle algorithm that combines Lagrangian and Eulerian schemes to discretise different parts of the governing equation and thereby exploits the strength of each scheme. In hrSPH the location of the particles is periodically reinitialised (remeshed) onto a uniform grid **Chaniotis** in which the conserved quantities are redistributed onto a new set of particles. The quantities are interpolated by the 3rd order $M'4$ **Monaghan** kernel, as shown in Figure 1.

FIGURE 1



(a) Particle-to-mesh interpolation and (b) mesh-to particle interpolation in *2D* using an interpolation function with support region $2h$ (shaded in yellow). Blue particles and mesh nodes are within the support region of the centre node/particle and hence assigned onto it. Green particles and nodes which lie outside the support are not considered.

THE HYBRID SMOOTH PARTICLE METHOD

A novel mesh based on high order Finite difference solver is implemented subject to several boundary conditions (free space, Neumann, periodic, etc...), a high grid resolution is achieved using particles and mesh patches of different resolution. Solid boundaries are implemented by a Brinkman penalisation **Liu.obeidat**

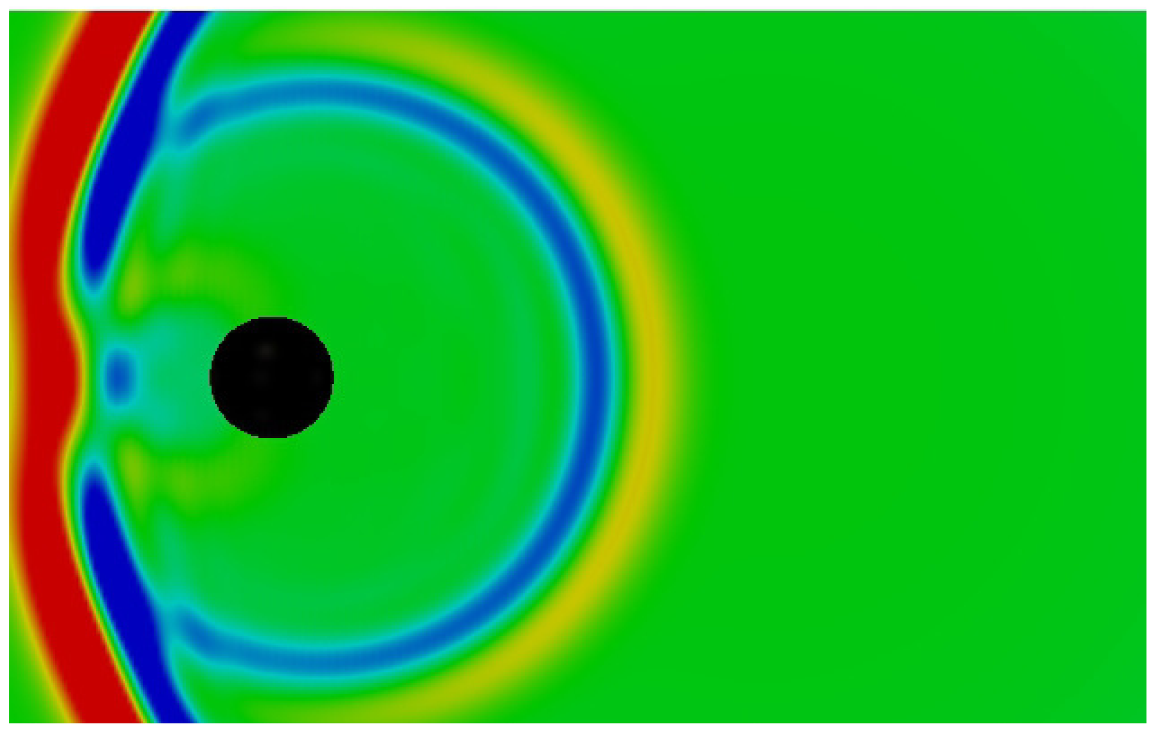
THE ALGORITHM

- The Eulerian part :
  The particles carrying their characteristic are interpolated to the grid via $M'4$ kernel, as shown in Figure 1 (a).
  On the grid we compute the right hand side of the governing equations (ex: the momentum equation.)
  The computed forces are interpolated back to the particles, as shown in Figure 1 (b).
- The Lagrangian part :
  This part takes place on the particle, where the interpolated forces are used to update the particles (diffusion, advection, aggregation, adhesive) .
  In other cases the forces between the particles as calculated directly on the Lagrangian part as a classical SPH method.
- Remeshing:
  In case of particle's distortion, remeshing is done through the same interpolation kernel.

VERFICATIONS

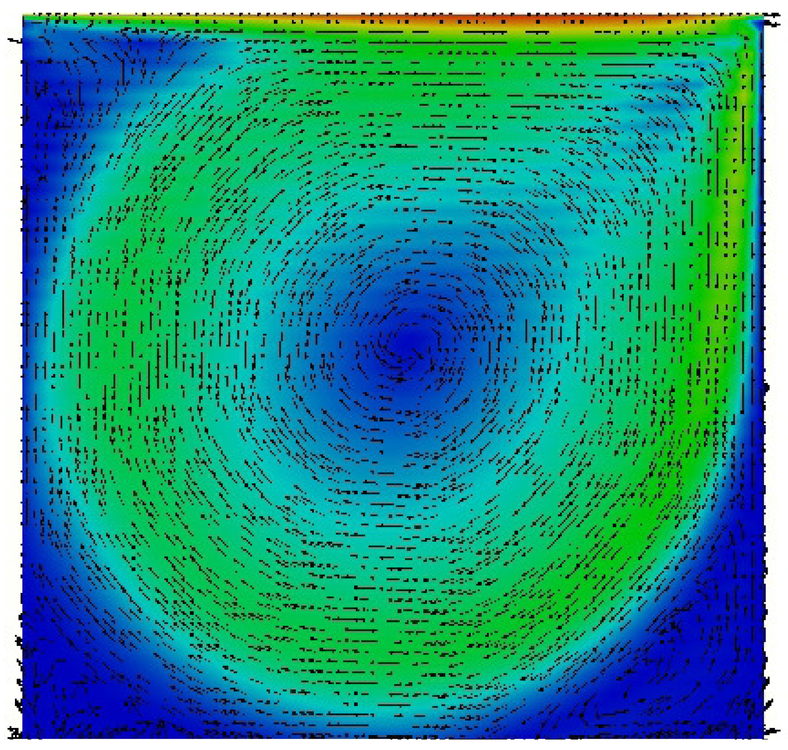
The method is verified via several compressible and weakly-compressible viscous flow benchmarks. Figure 3 shows a compressible shock wave perturbation pressure simulation with high Mach number. The method is also able to simulate viscous flow with high Reynolds number, Figure 4 represents a lid-driven cavity simulation for Reynolds number $= 10^4$. For turbulence flow we model the turbulent sub-grid stresses using the standard Smagorinsky model and one equation large eddy simulation (LES) as shown in Figure 5.

FIGURE 2



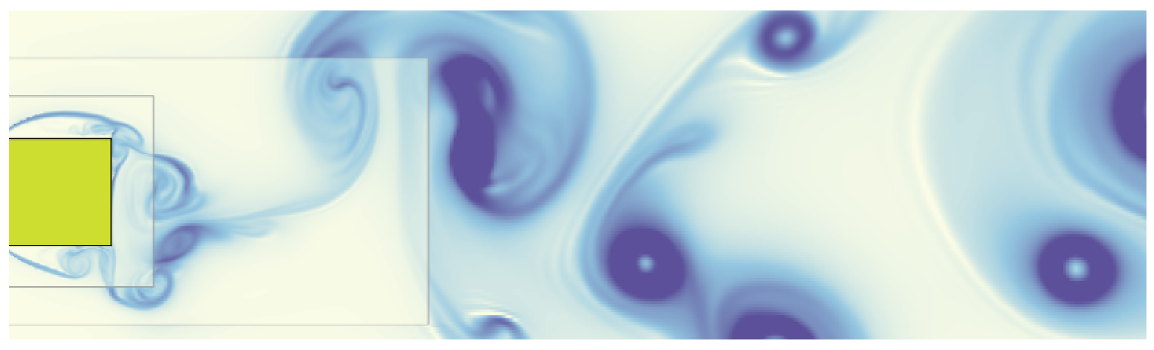
Compressible shock wave perturbation pressure simulation, here we can see the first reflected wave off the solid obstacle.

FIGURE 3



Lid-driven cavity velocity magnitude fields with vectors fields for Reynolds number $Rey = 10^4$.

FIGURE 4



Transported eddy viscosity of an LES simulation of the flow around a square cylinder using the kinetic turbulent energy transport equation

FUTURE APPLICATIONS

the work is being extended providing a high performance three dimensional Eulerian Lagrangian platform for the simulation of Biomed problems. Currently the work involved:

- Red blood cells deformation simulations
- Computational Optimisation of Cell Culture in a Microfluidic Device.
- Biofilm growth

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