# A Mesh Adaptation algorithm for highly deforming domains in the Particle Finite Element Method

**Thomas Leyssens*** **and Jean-François Remacle**†

* Université Catholique de Louvain,
Louvain-la-neuve, Belgium
e-mail: thomas.leyssens@uclouvain.be

† Université Catholique de Louvain,
Louvain-la-neuve, Belgium
e-mail: jean-francois.remacle@uclouvain.be

## ABSTRACT

Highly deforming domains are a recurring problem in fluid mechanics. In domains bounded by a free surface, for instance, the evolving boundaries need to be accurately represented at all times. In such situations, Lagrangian methods are a judicious choice for their ability to track material points in an evolving domain. The Particle Finite Element Method[1], or PFEM, has the ability to capture such strong domain deformations.

In the PFEM, the fluid is represented by a set of particles. At each time step, these particles are triangulated. The conservation equations are solved on this triangulation using the finite element method to obtain the material velocity of each particle. Using this velocity, the particles' positions are updated, resulting in a deformed domain which can be triangulated again at the next time step.

It is important to note that merely triangulating the particles is not enough. Indeed, there is no unique definition of the boundary of a set of points in 2D or 3D. A geometrical algorithm, known as the $\alpha$-shape of a triangulation[2], is therefore employed to define the shape of the fluid domain. Since this algorithm depends on quality and size aspects of the elements in the triangulation, properly adapting the mesh is key to the success of the method.

In this work, we propose an approach to adapt the mesh with theoretical guarantees of quality. The approach is based on Delaunay refinement strategies[3], allowing to adapt the mesh while maintaining high quality elements. The interest of using Delaunay Refinement techniques is twofold. First of all, the algorithm for the domain boundary recognition, the $\alpha$-shape, is strongly connected to the Delaunay triangulation of a set of points. The algorithm proposed in this presentation imposes a theoretical lower bound on the quality of all the elements in the mesh, ensuring an accurate detection of the fluid domain. Second, the algorithm is supported by a mesh size field in order to allow local mesh refinement. Along the free surface, for instance, greater refinement is diserable such that domain deformations, separations and merges of the fluid domain are well-captured.

During the presentation, we first briefly present our approach to the PFEM, including special considerations on boundary conditions. Next, the mesh adaptation algorithm is described, followed by simulation results. We are confident that this method will allow to simulate situations of complexe domain evolutions with a limited degree of refinement and complexity.

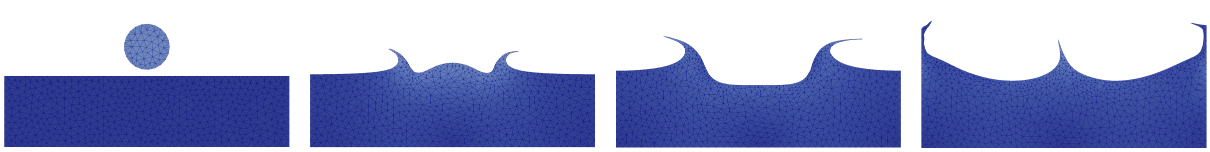

**Figure 1**: Simulation of a falling water drop using our mesh adaptation approach in the PFEM.

## REFERENCES

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