University of Liège, Belgium.
Aerospace and Mechanical Engineering Department,
Computational Non-Linear Mechanics Laboratory (LTAS-MN2L)

A new remeshing strategy relying on level-set functions for the Particle Finite Element Method

COUPLED 2023

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Simon Février, Martin Lacroix, Luc Papeleux, Romain-Boman, Jean-Phillipe Ponthot

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Introduction : PFEM

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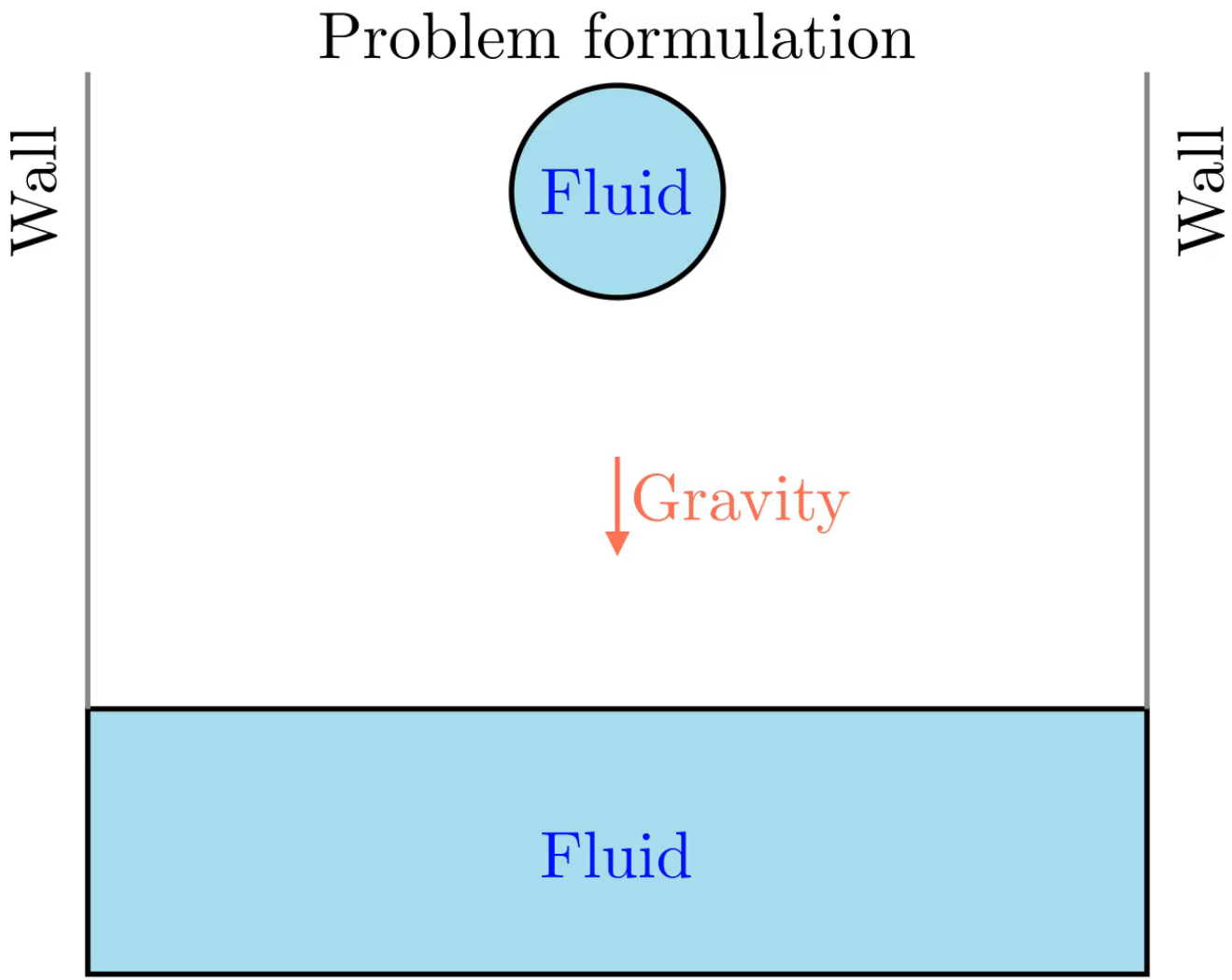

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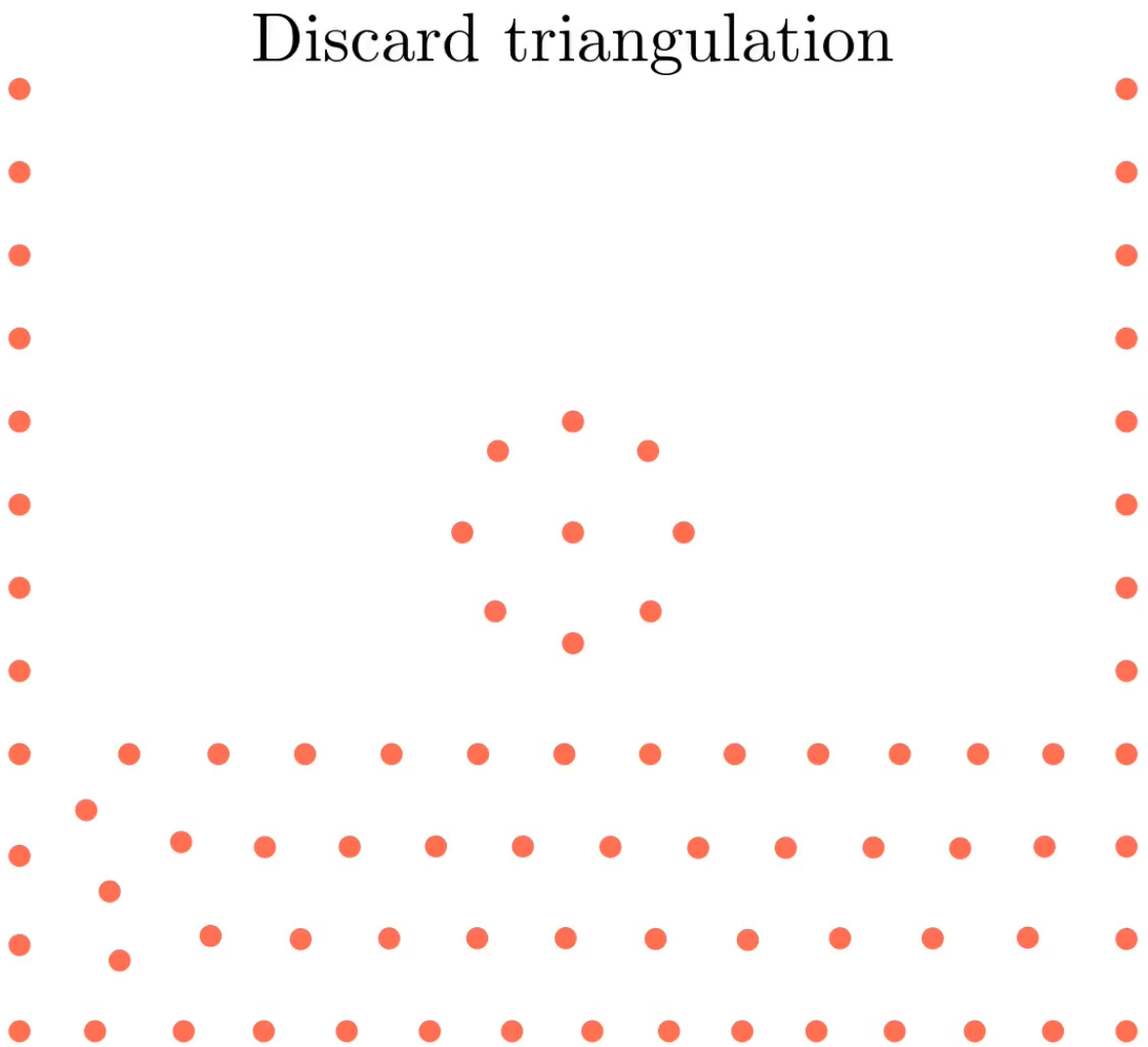
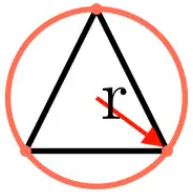


Apply Alpha-Shape Algorithm

(Alpha-Shape Algorithm)



h_u : Reference size

r : Circumradius

α : Alpha Shape

$$\alpha = \frac{r}{h_u} = 1.02$$

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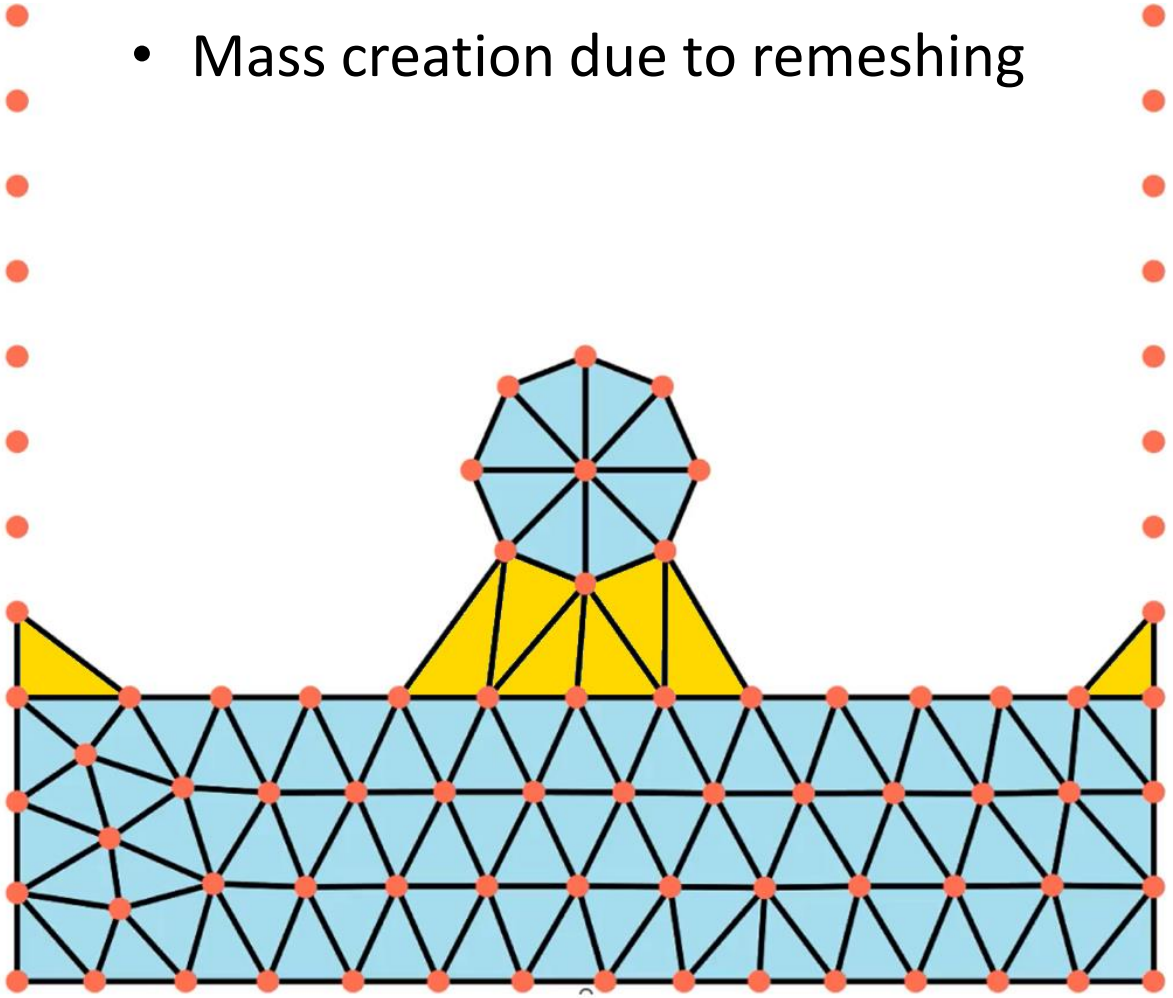

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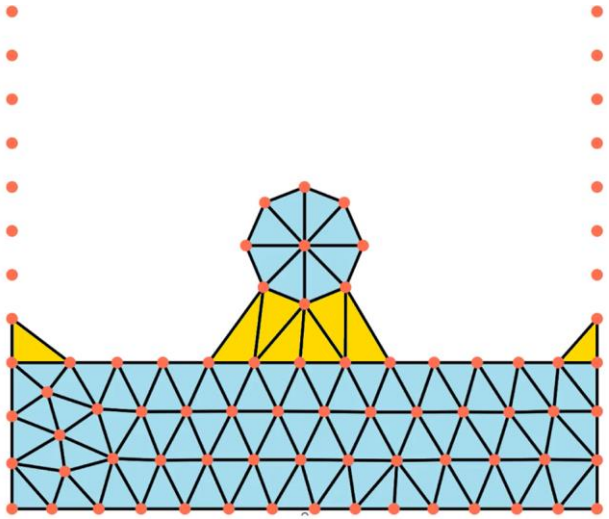

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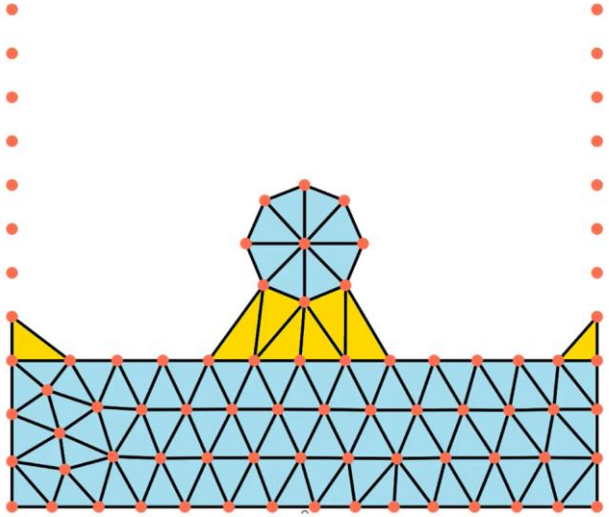

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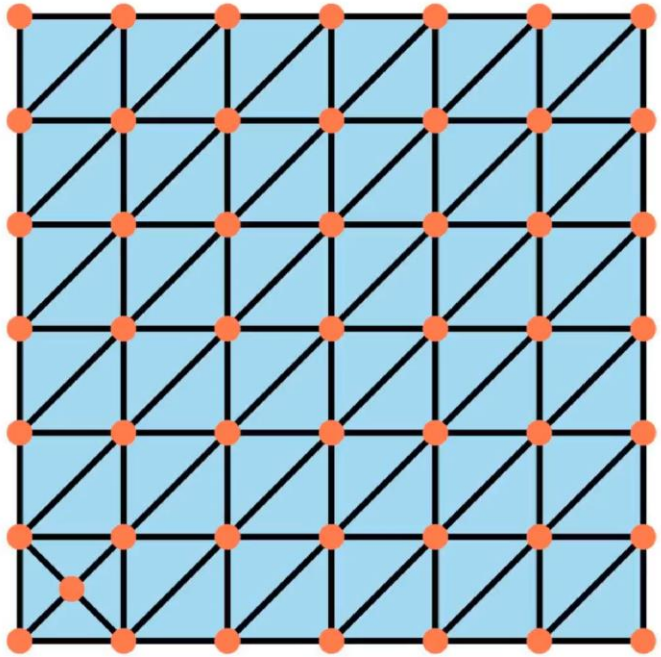

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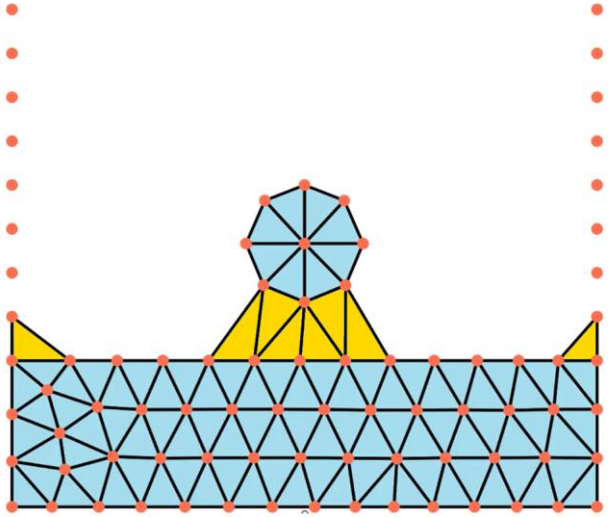

- Mass removal due to remeshing
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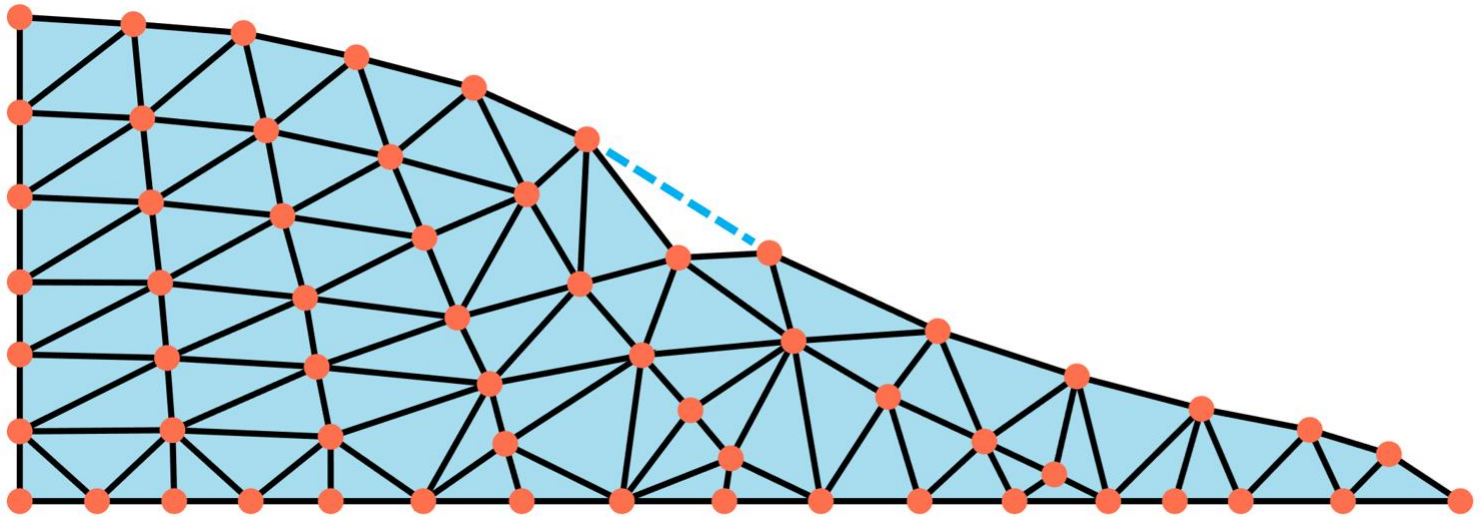

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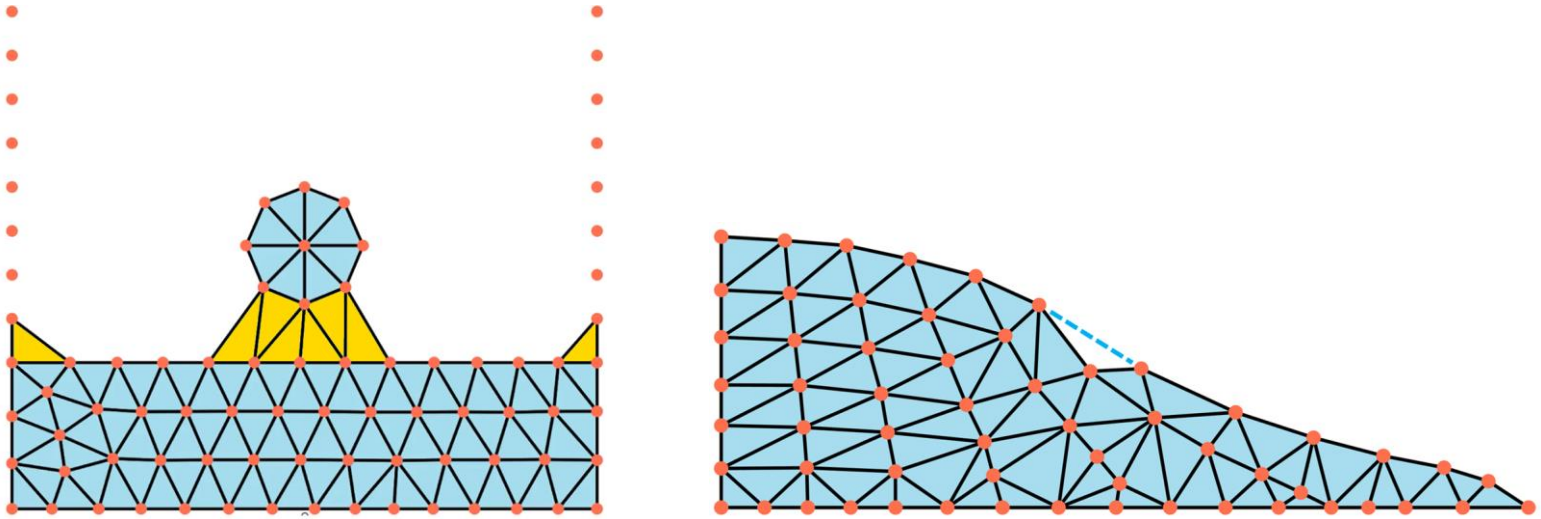

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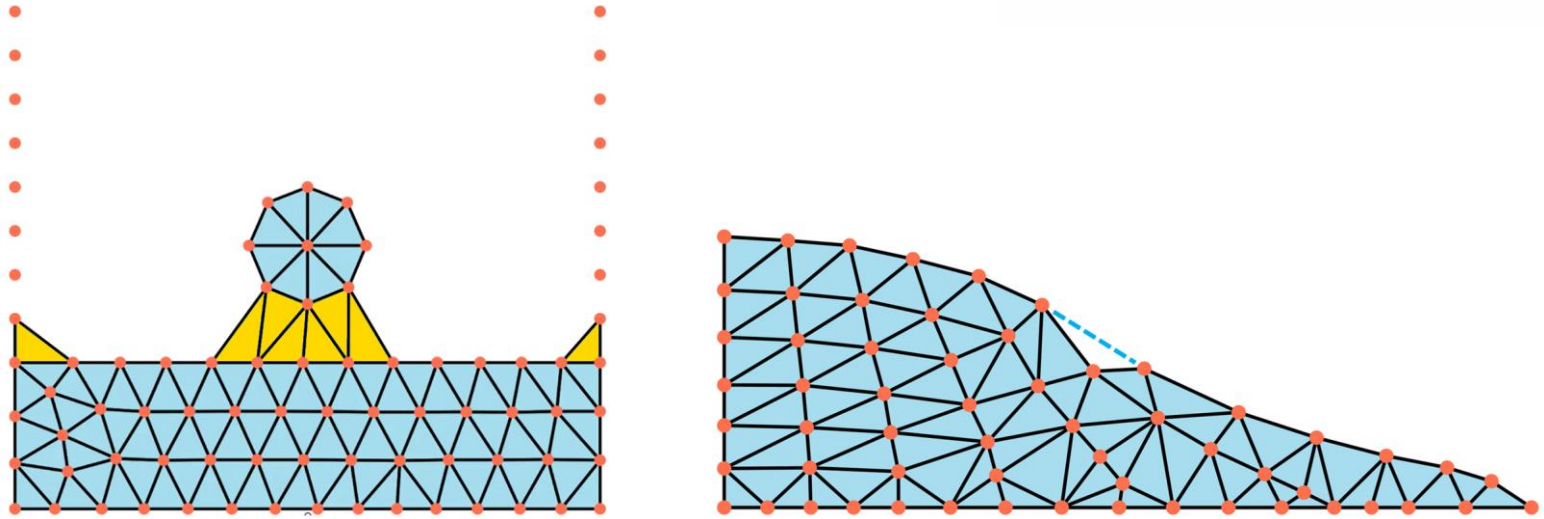

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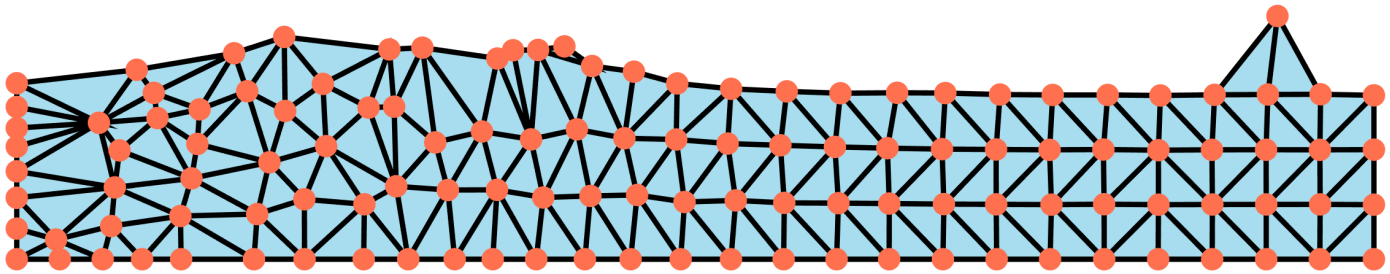

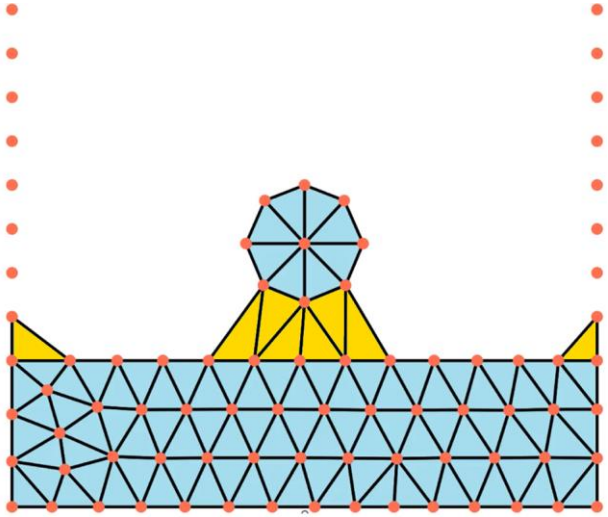

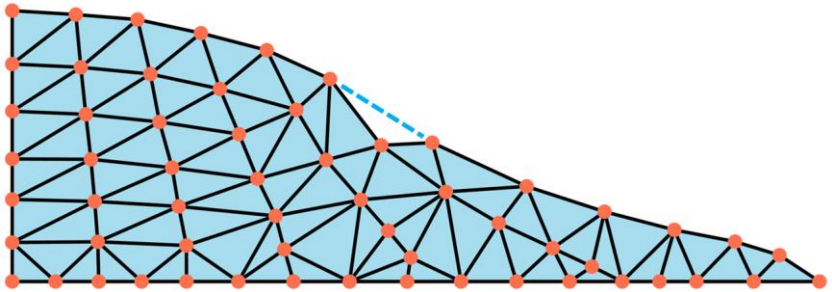

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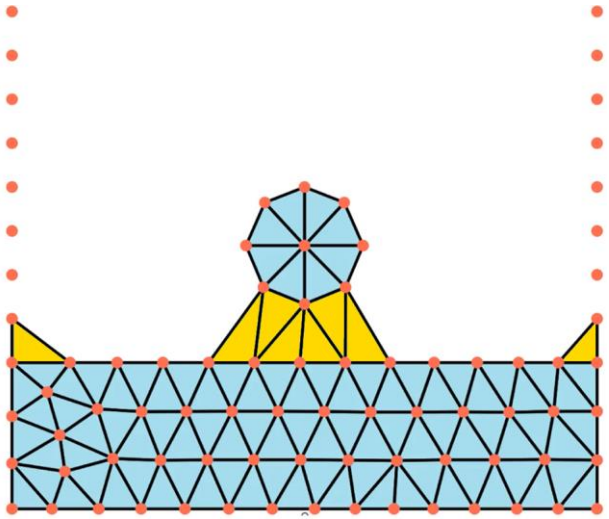

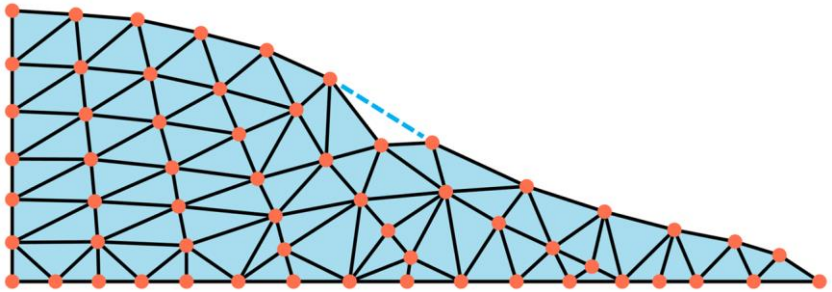

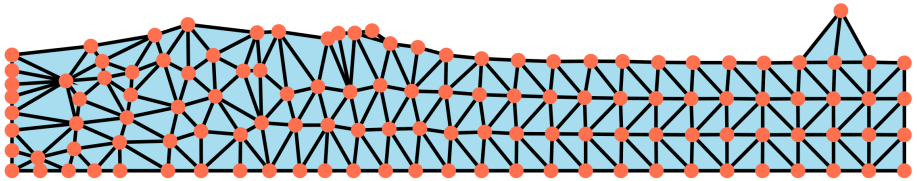

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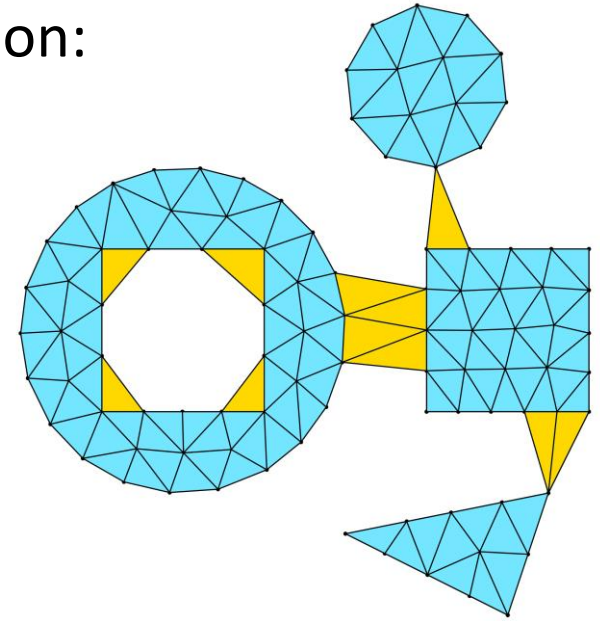

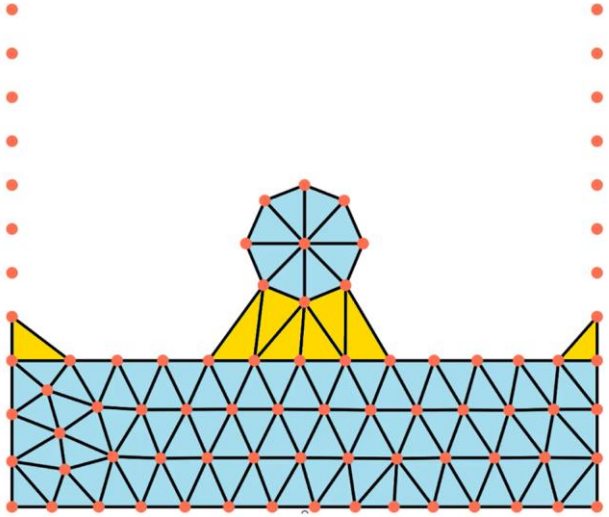

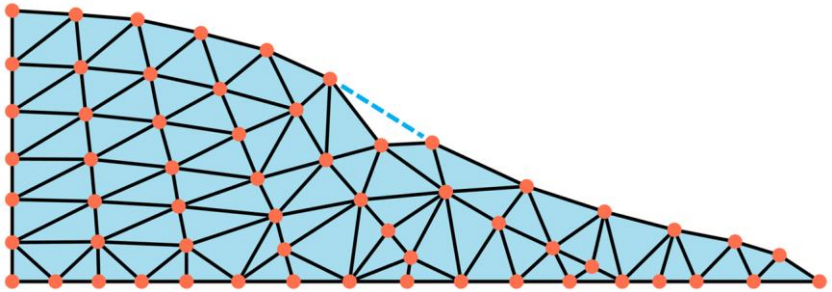

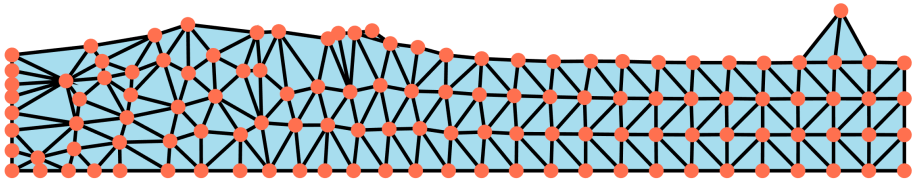

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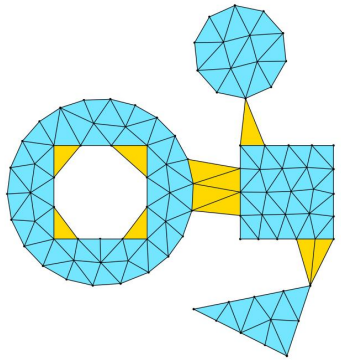

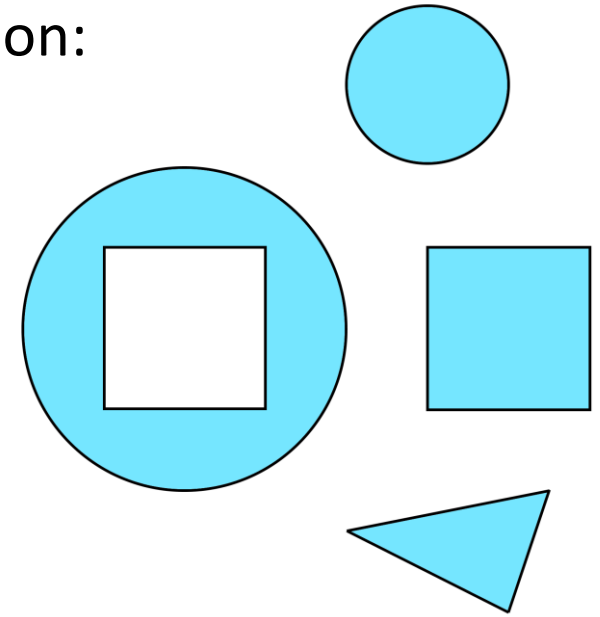

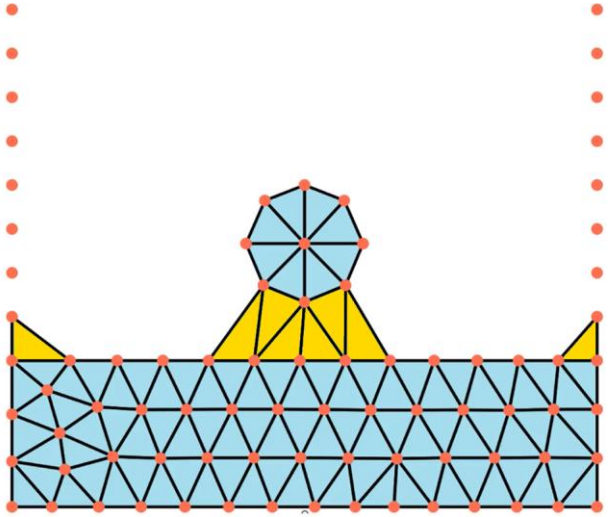

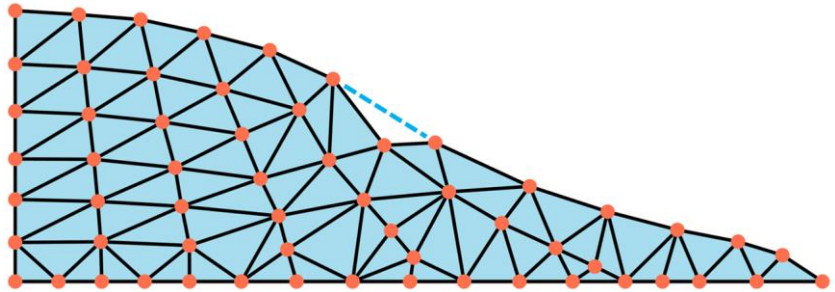

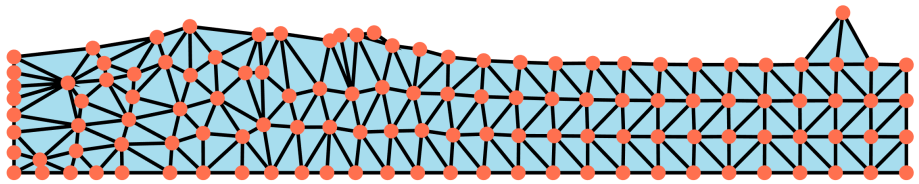

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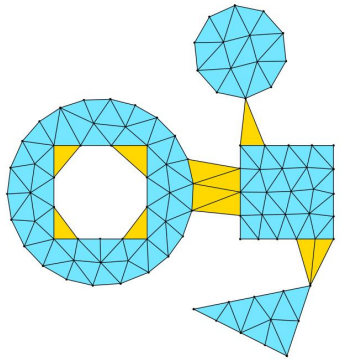

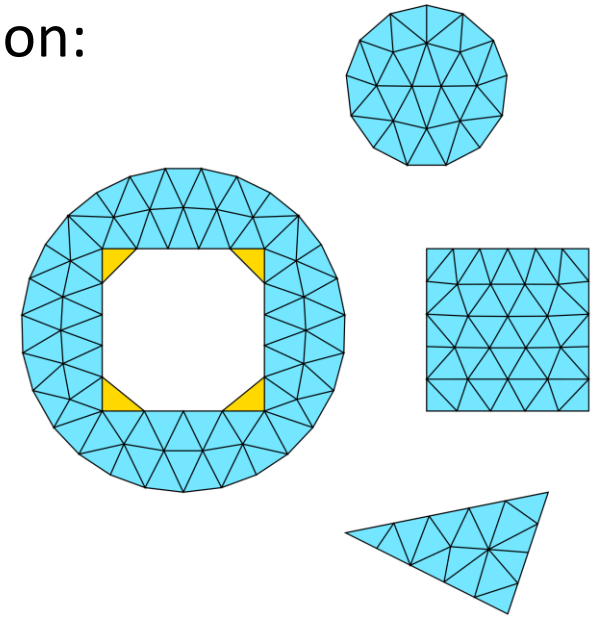

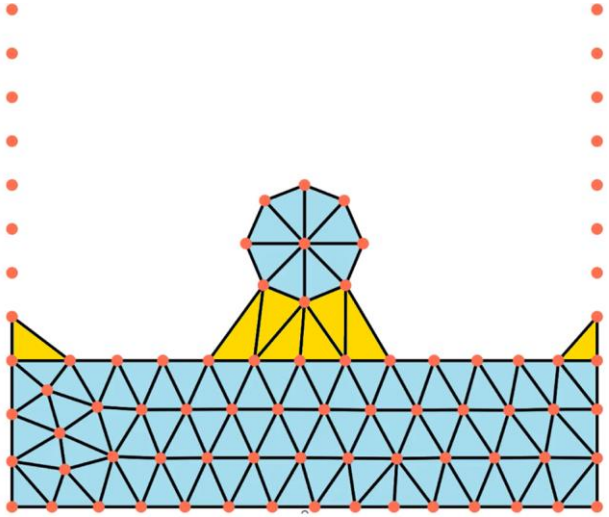

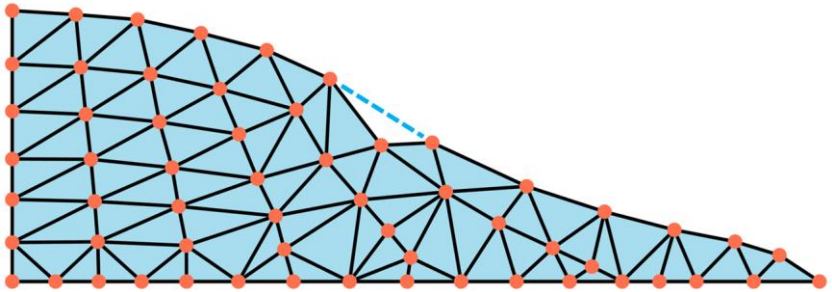

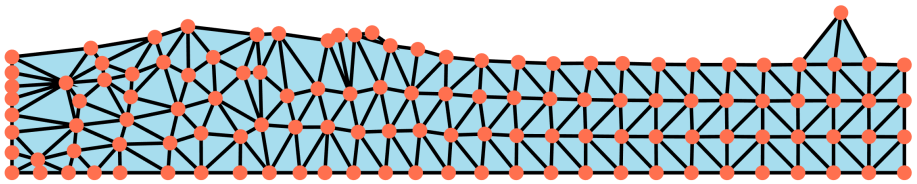

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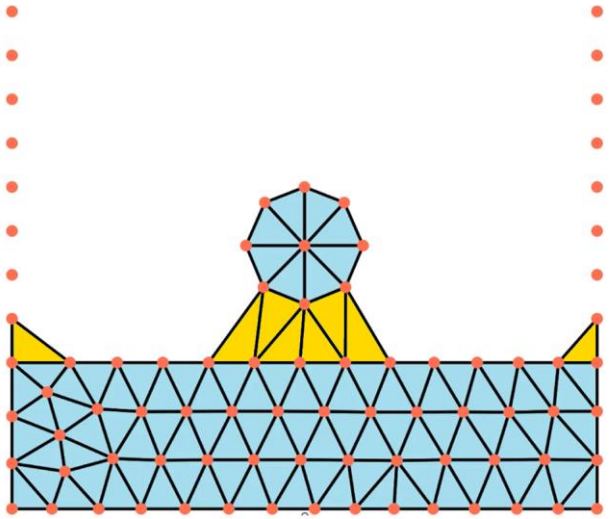

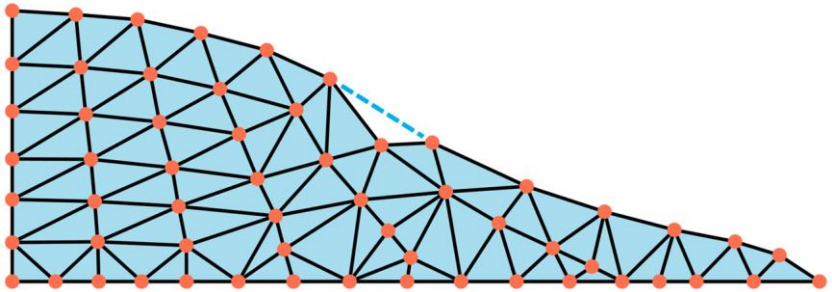

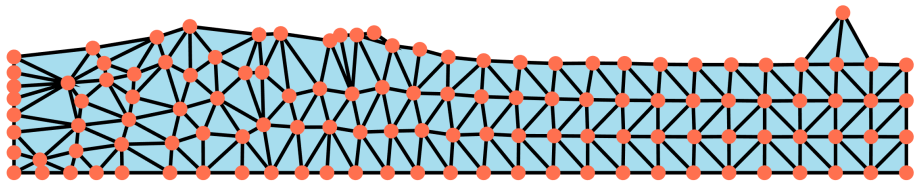

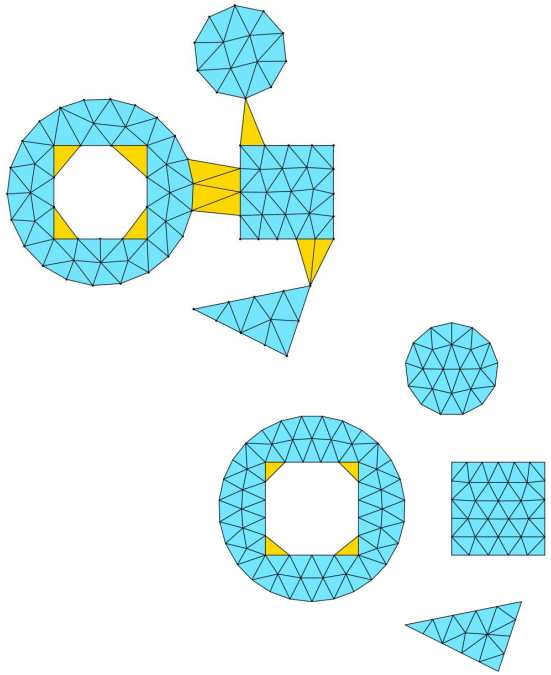

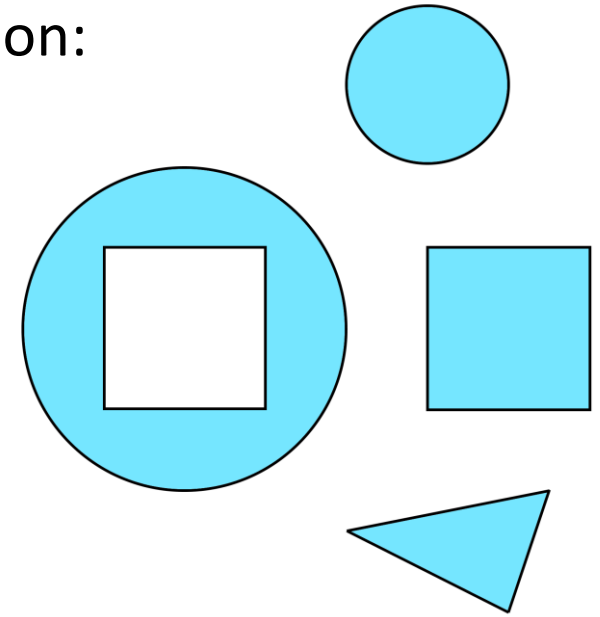

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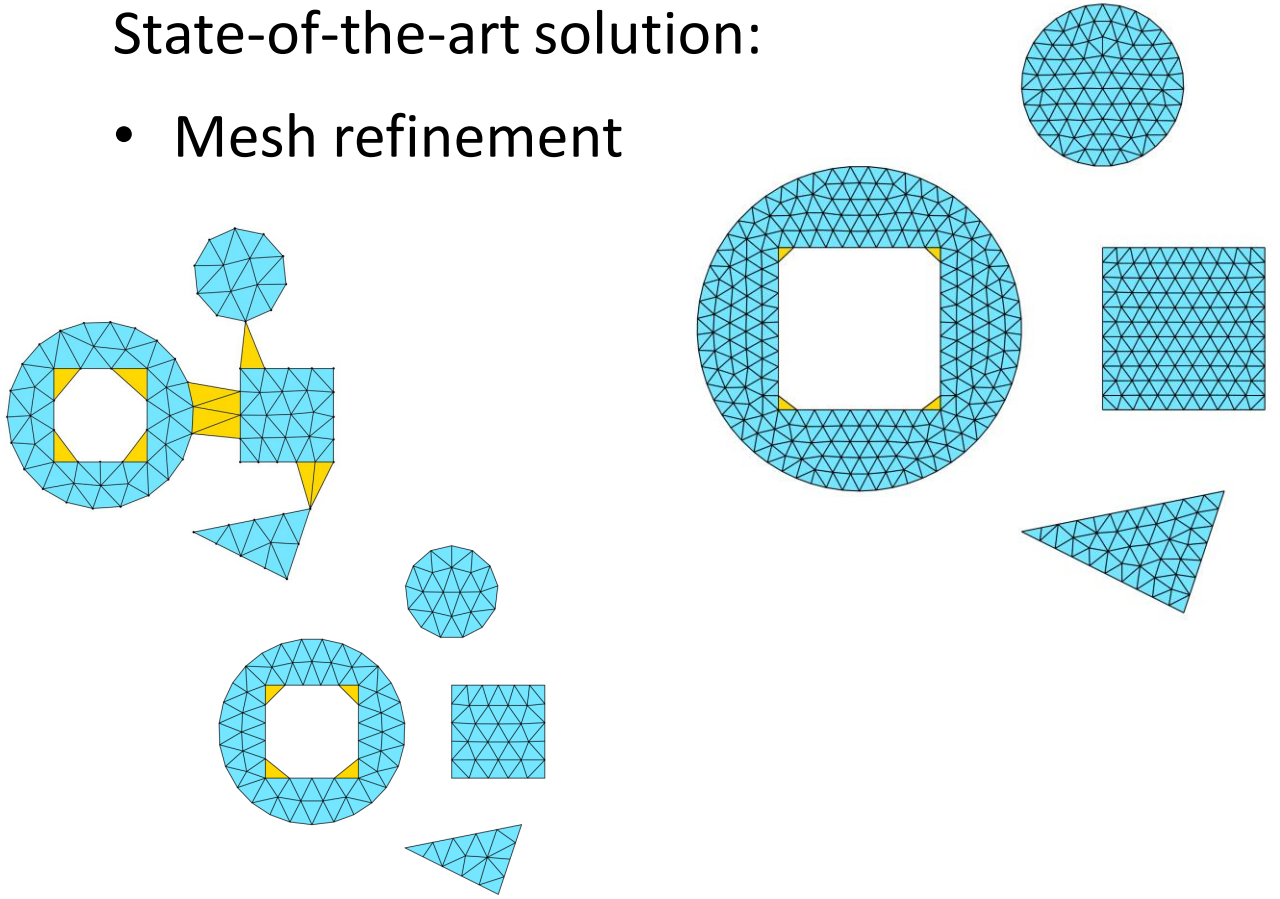

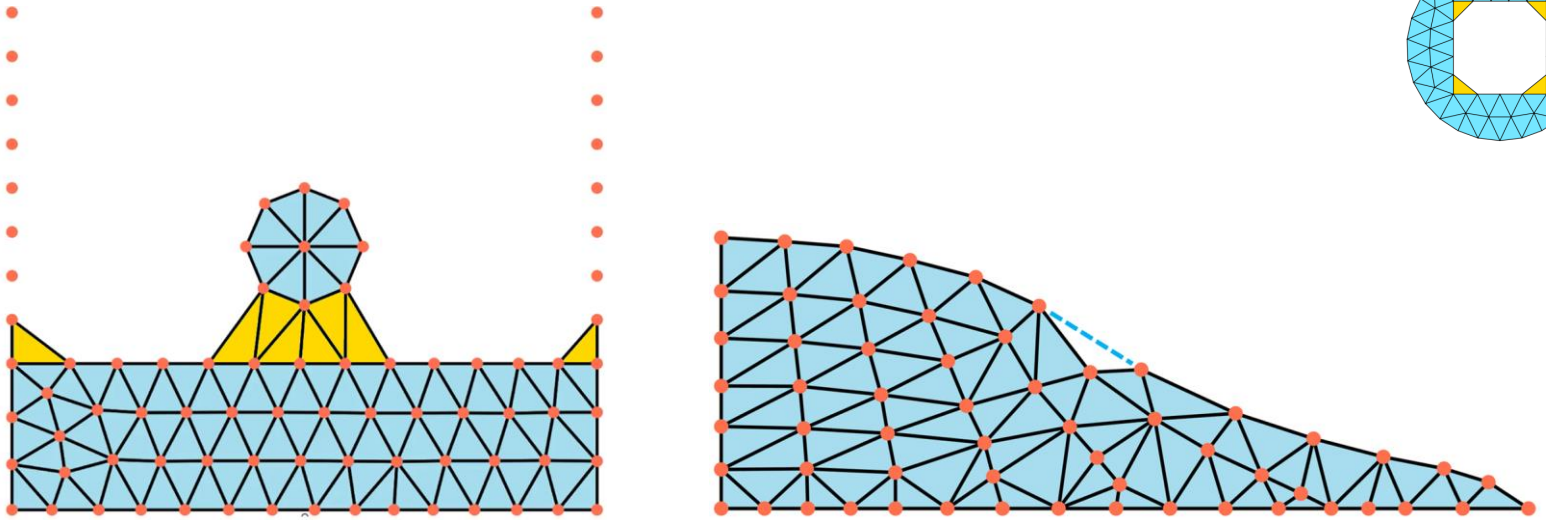

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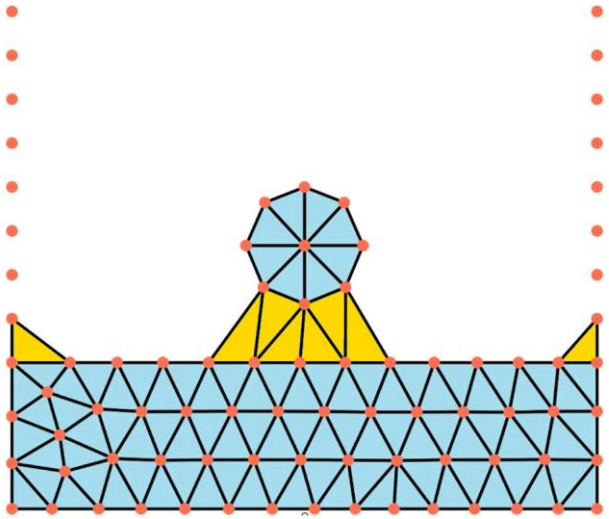

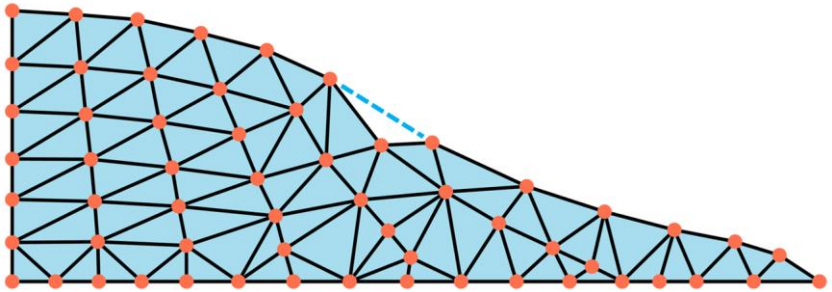

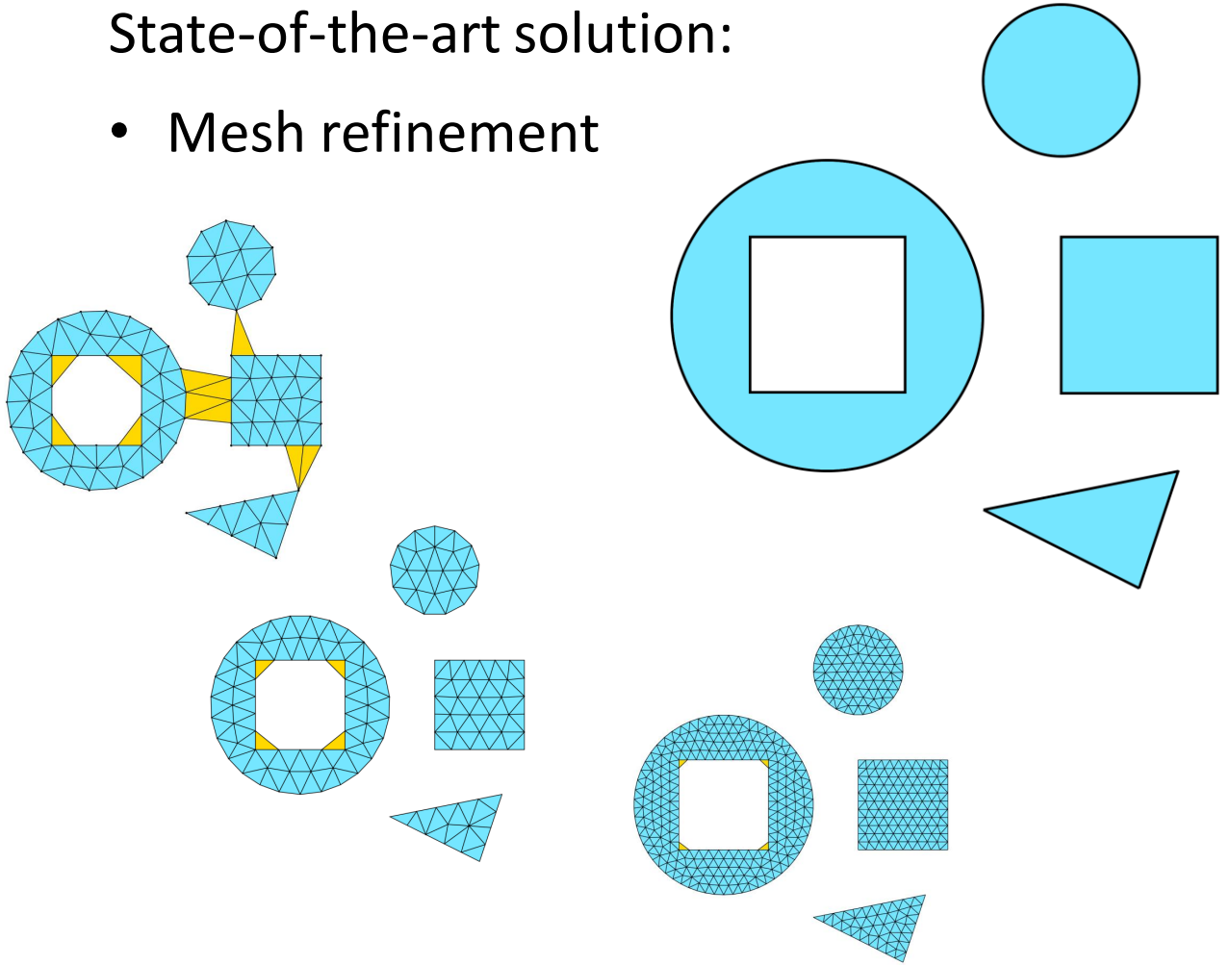

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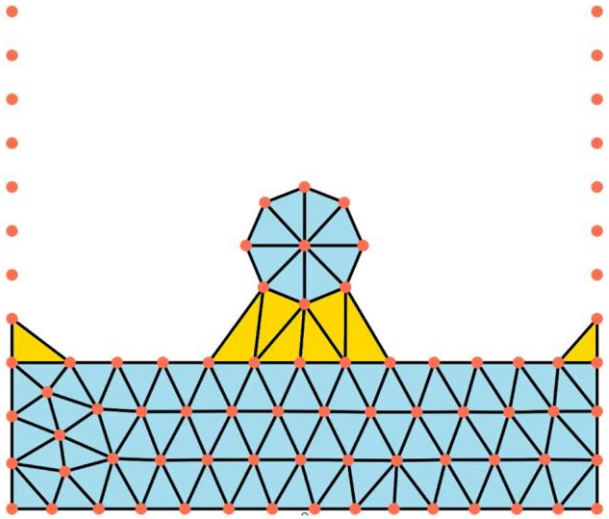

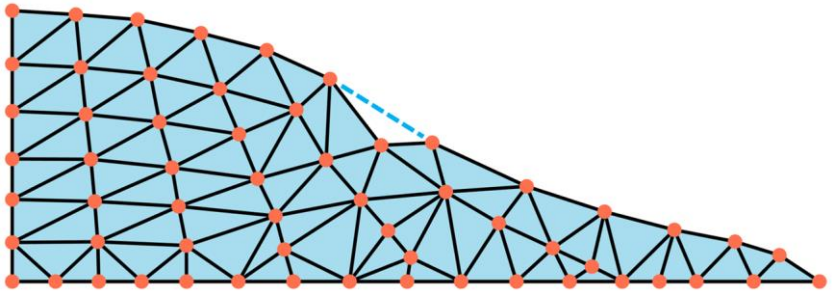

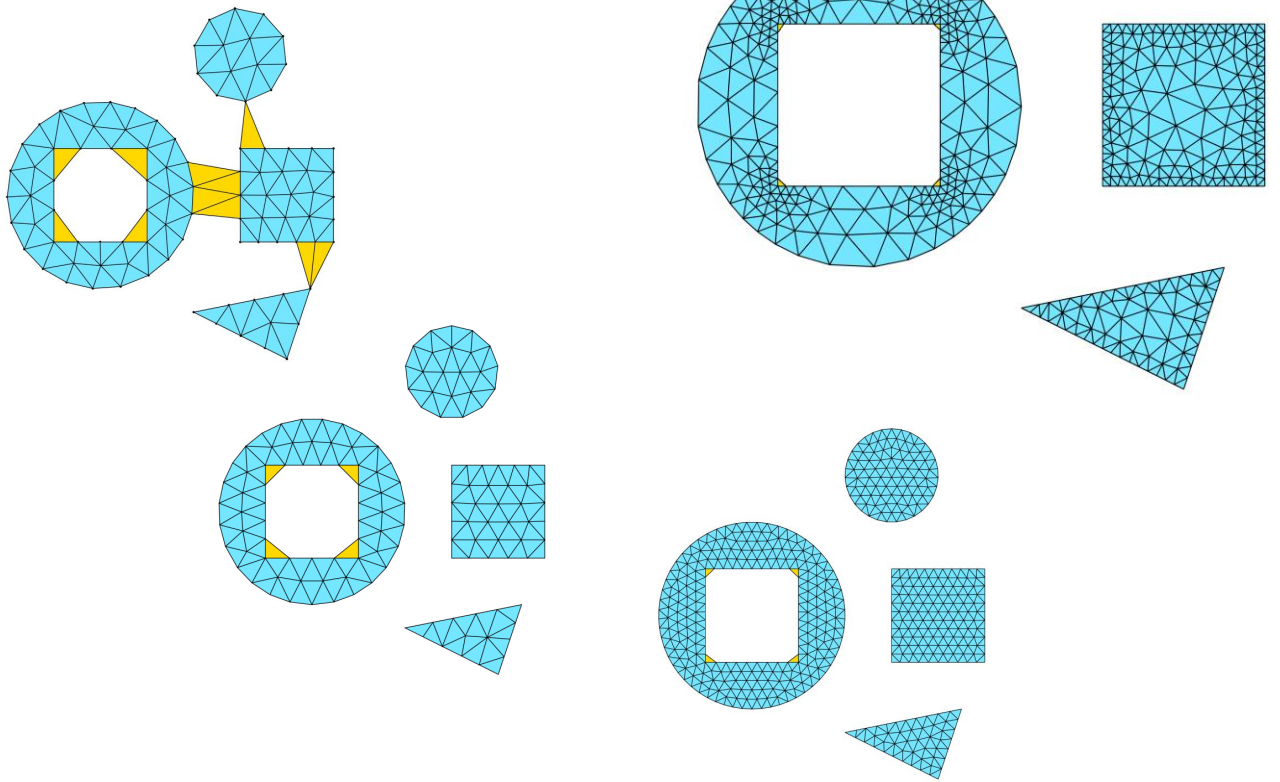

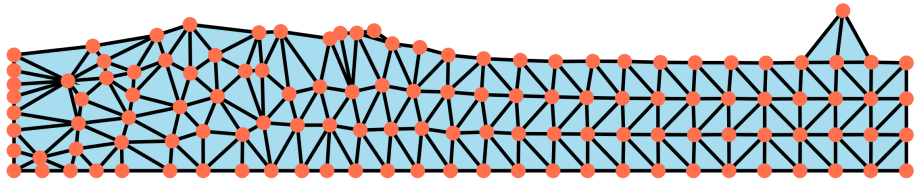

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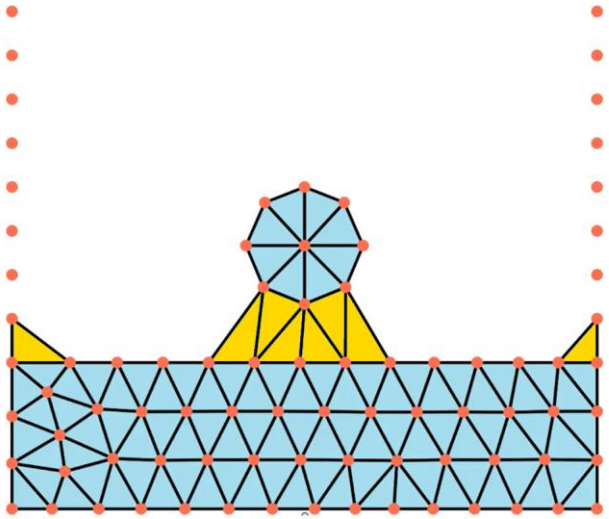

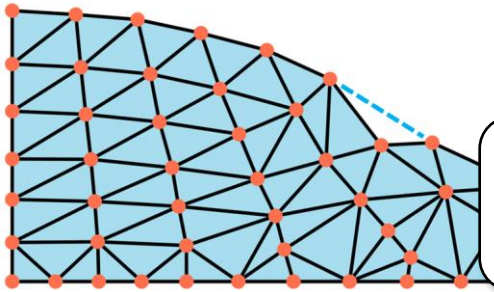

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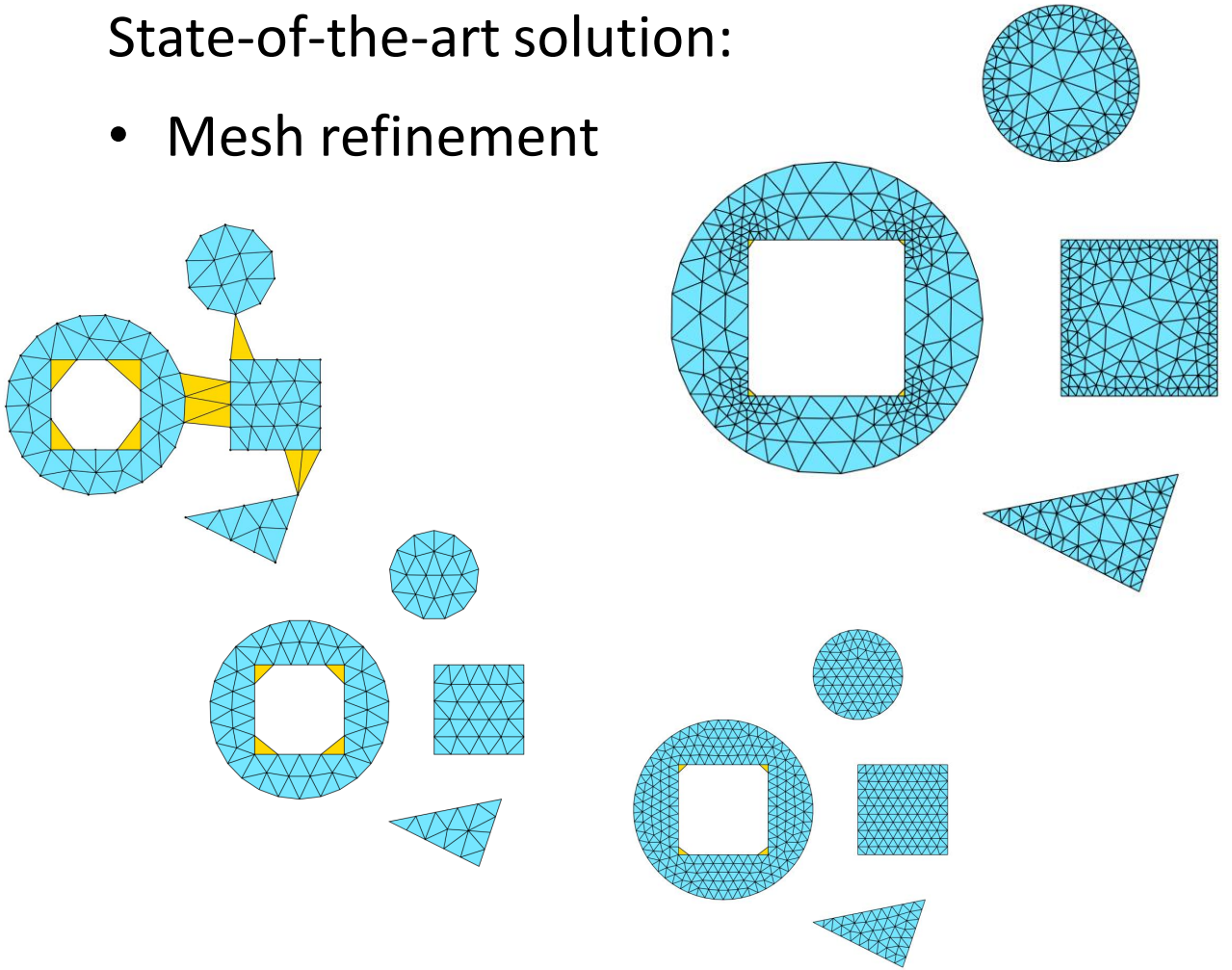

Falla, R., Bobach, B. J., Boman, R., Ponthot, J. P., & Terrapon, V. E. (2023). Mesh adaption for two-dimensional bounded and free-surface flows with the particle finite element method. *Computational Particle Mechanics*, 1-28.

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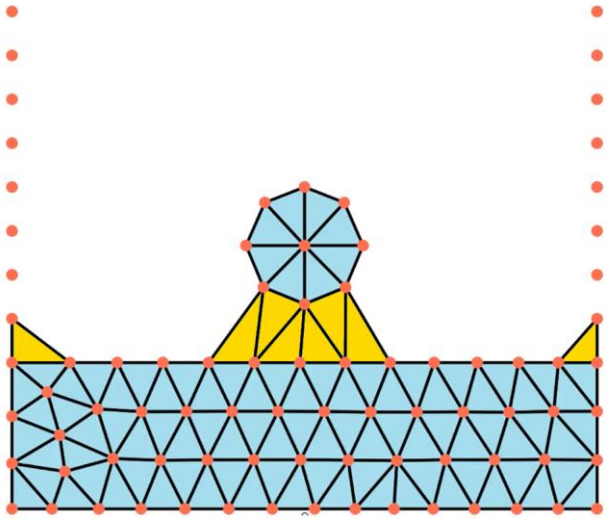

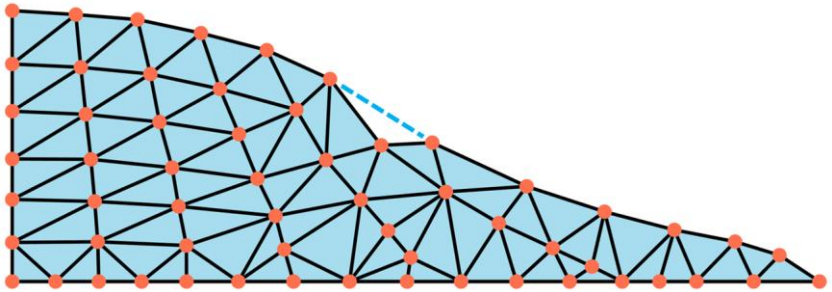

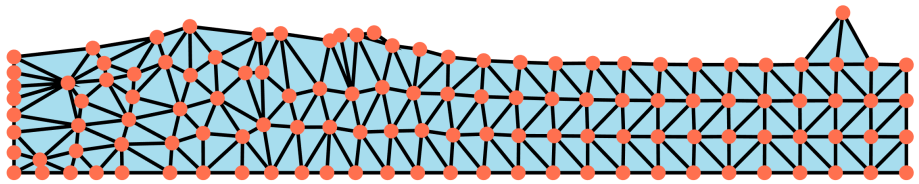

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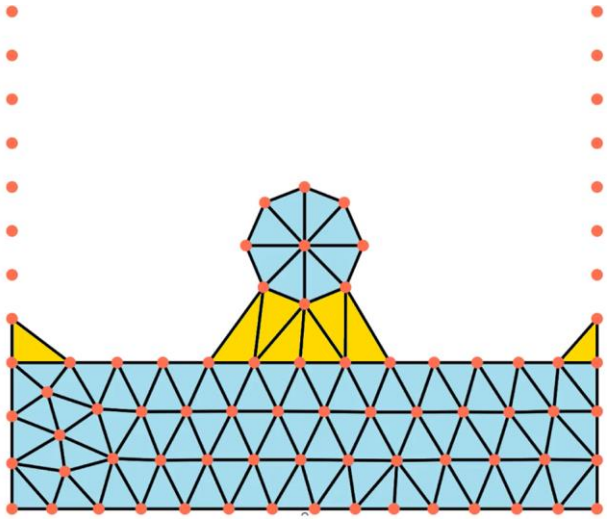

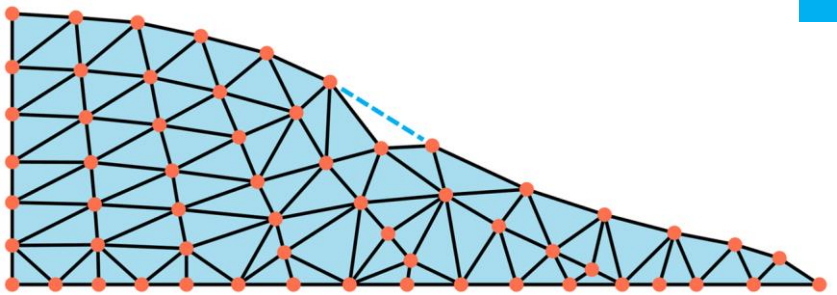

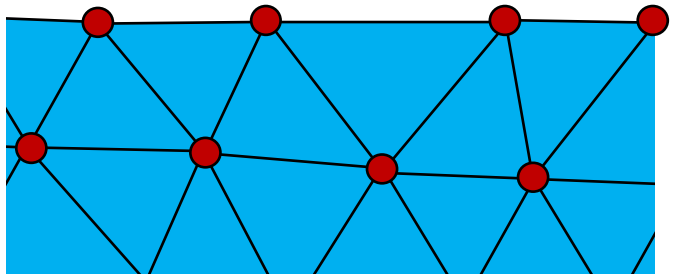

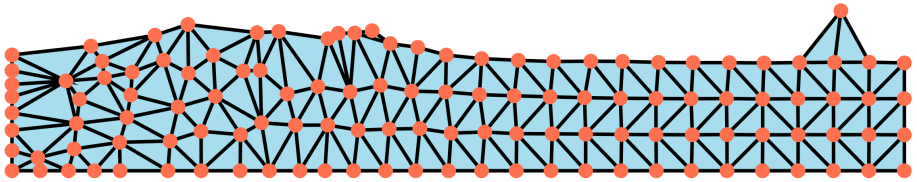

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Difficulties in PFEM :

- Mass creation due to remeshing
- Mass removal due to remeshing
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State-of-the-art solution:

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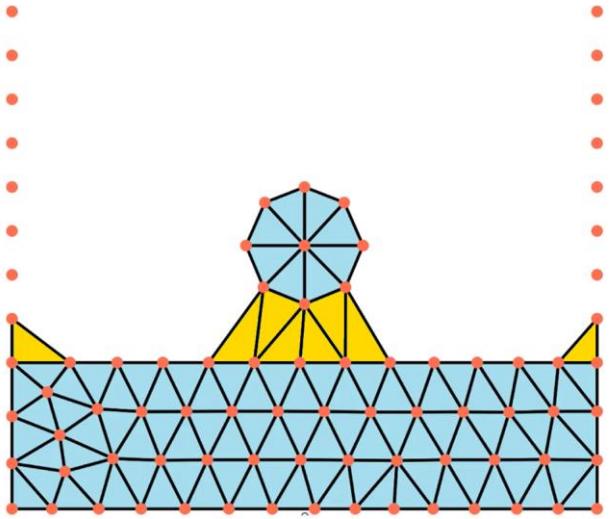

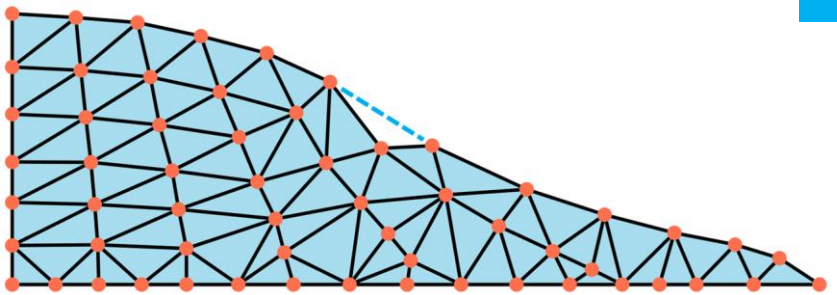

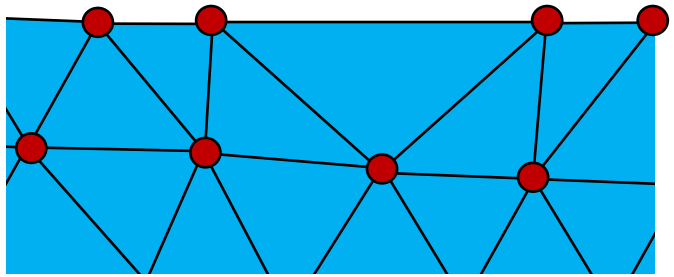

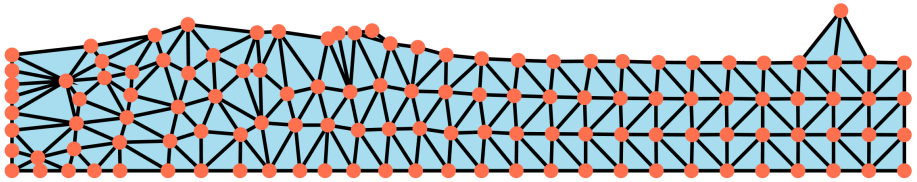

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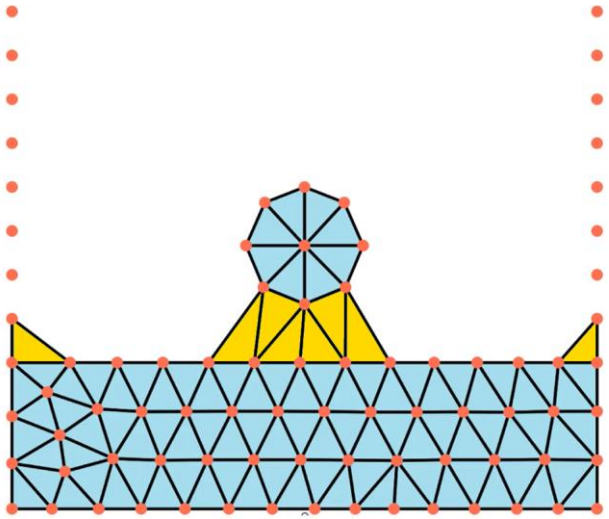
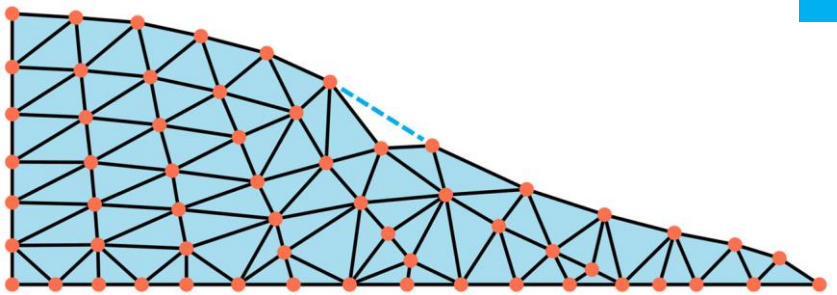
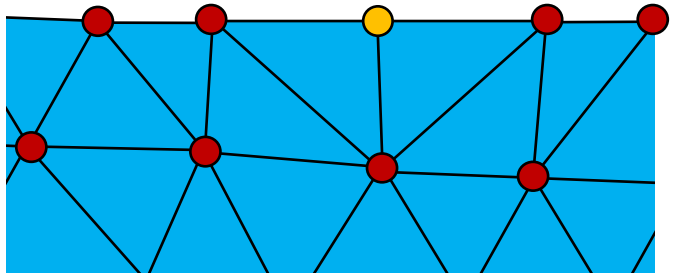
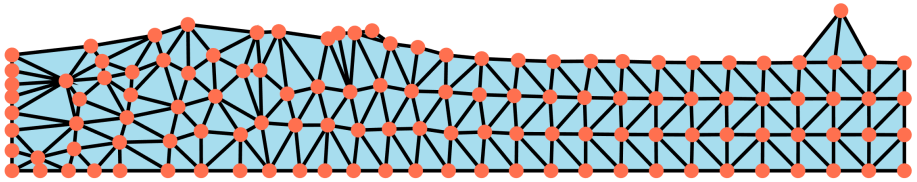
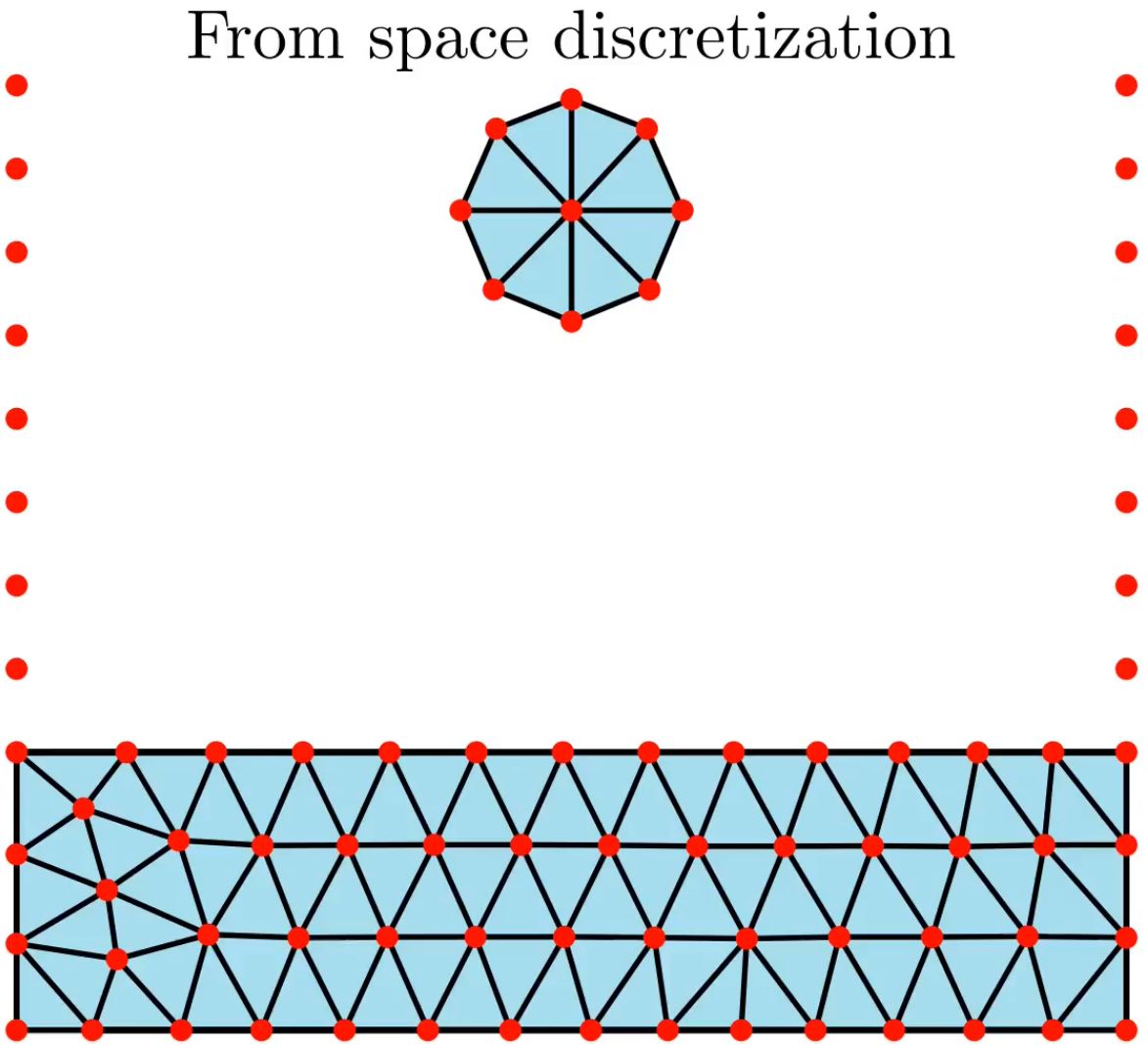








Remeshing strategy based on Level Set functions



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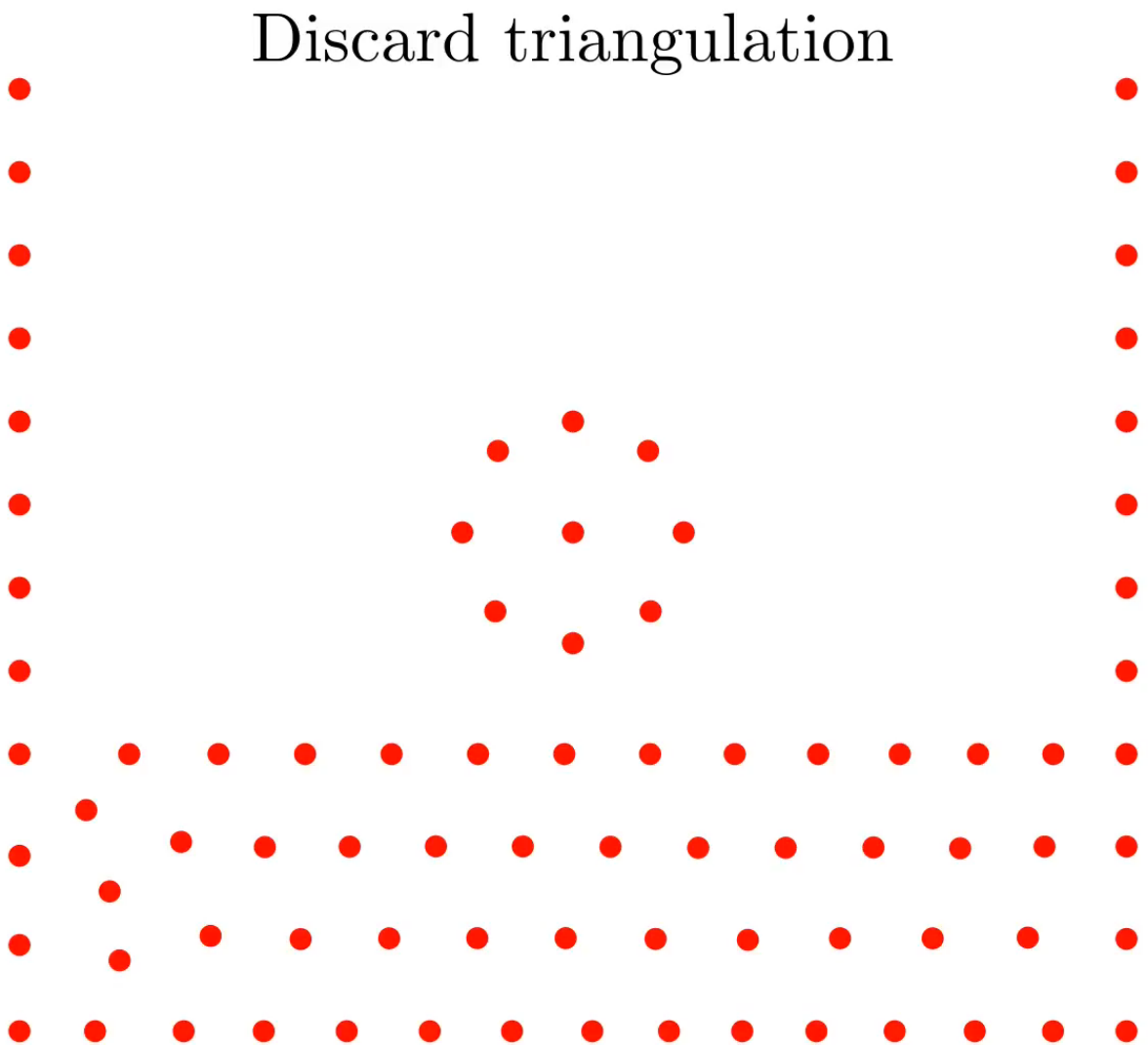
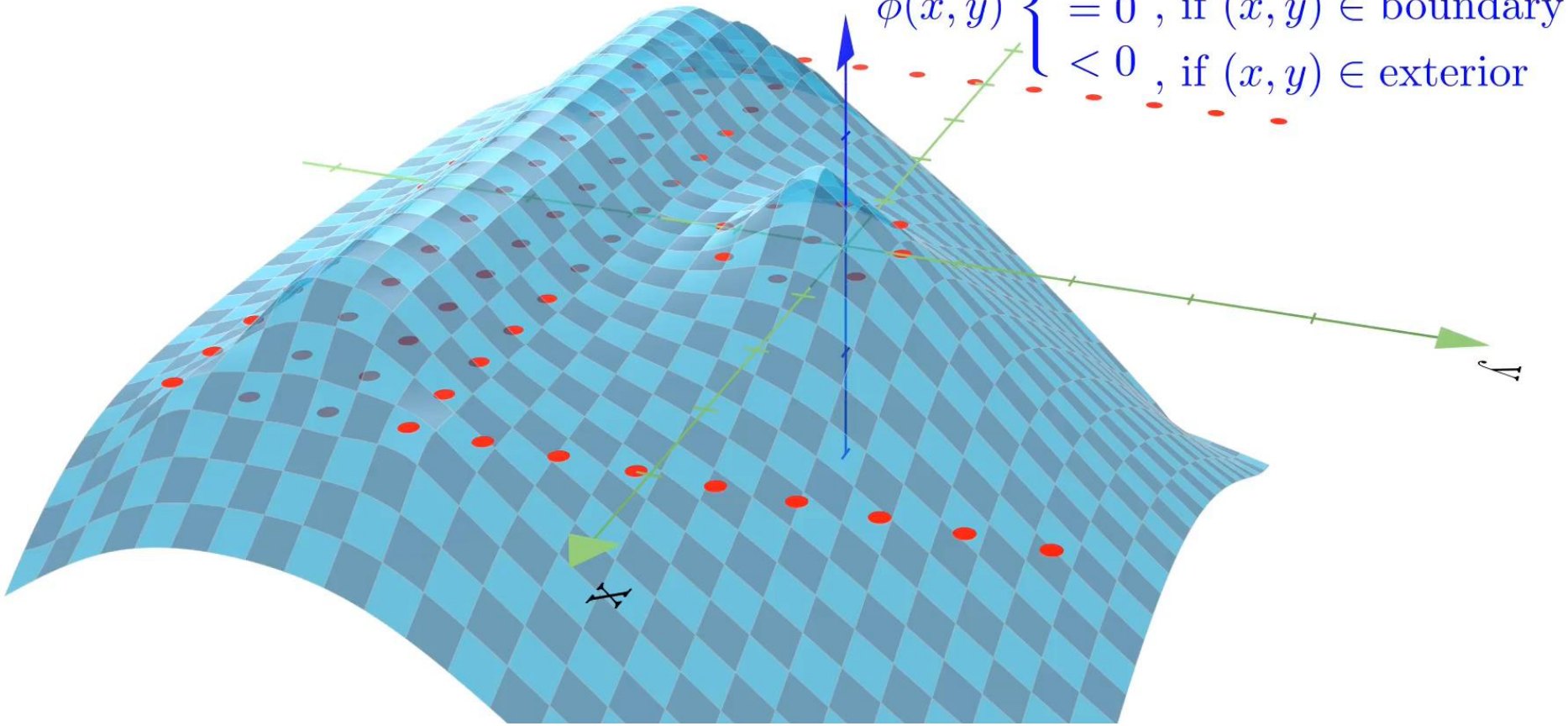


Remeshing strategy based on Level Set functions

Build Level Set function at t_{n+1}

$$\phi(x,y) \begin{cases} > 0 \text{ , if } (x,y) \in \text{interior} \\ = 0 \text{ , if } (x,y) \in \text{boundary} \\ < 0 \text{ , if } (x,y) \in \text{exterior} \end{cases}$$



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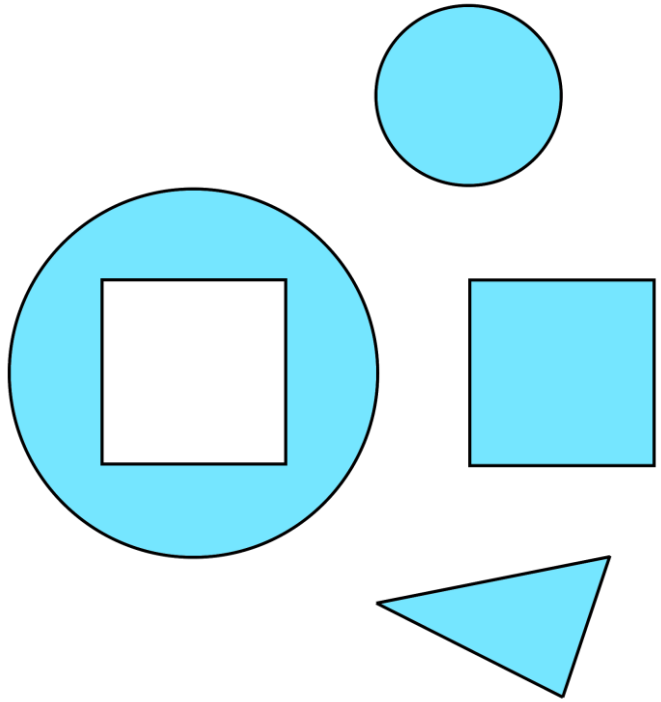

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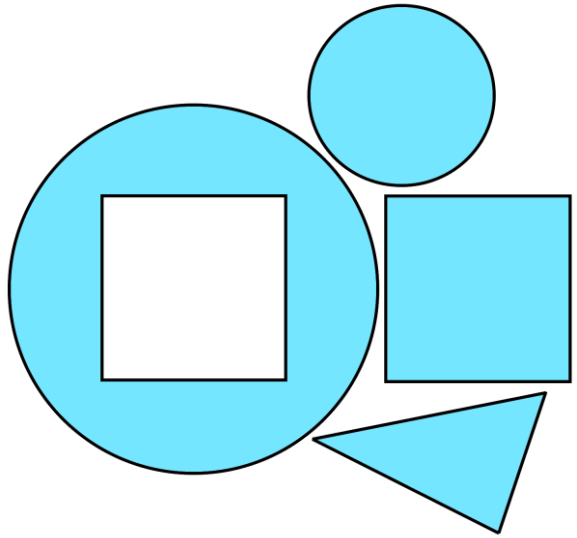

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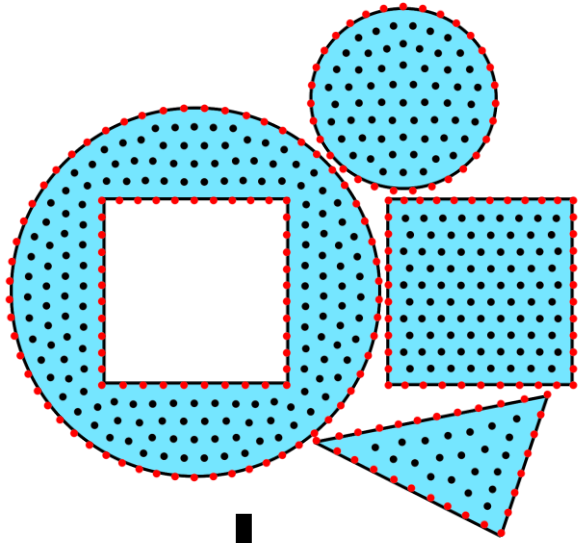
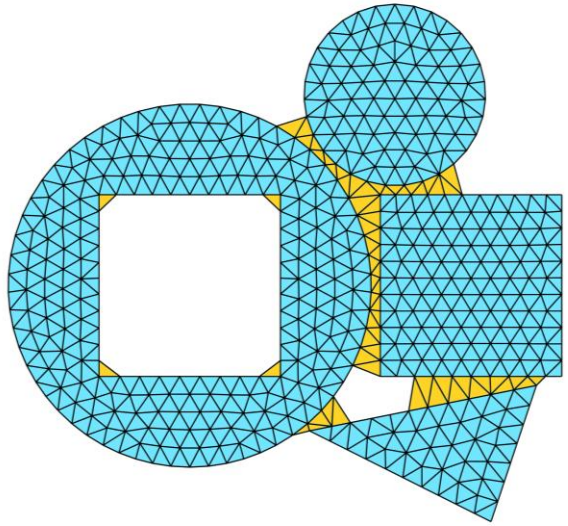


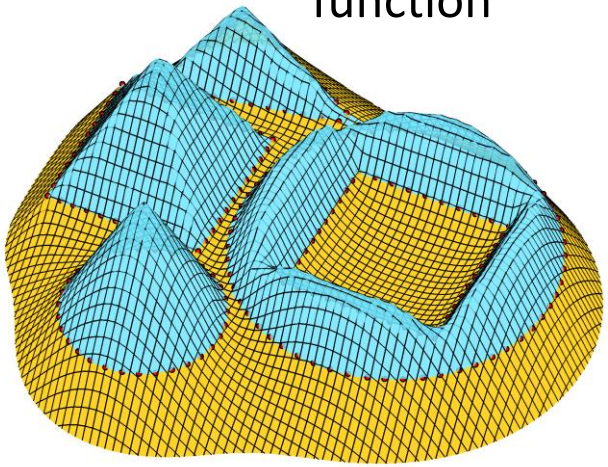
Delaunay Triangulation
+ Alpha Shape (AS)



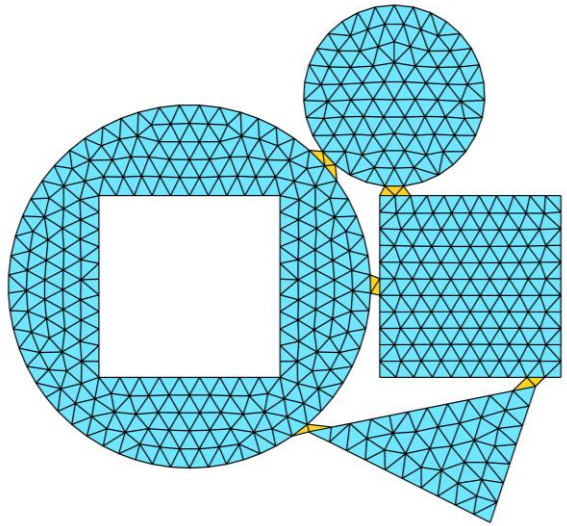
PFEM-AS

Particle Finite Element Method based on Alpha-Shapes

Build Level-Set function



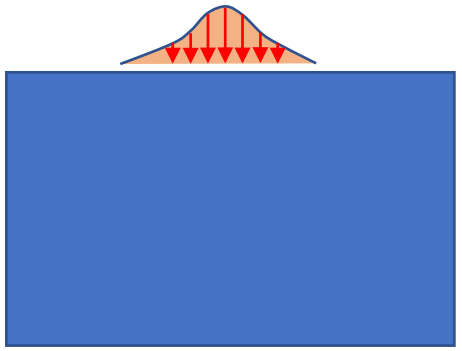
Delaunay Triangulation
+ "Distance" criterion



PFEM-LS

Particle Finite Element Method based on Level-Sets

Examples (1/3) : Laser Melting Simulation



Heat equation

+

Navier-Stokes Eqs.

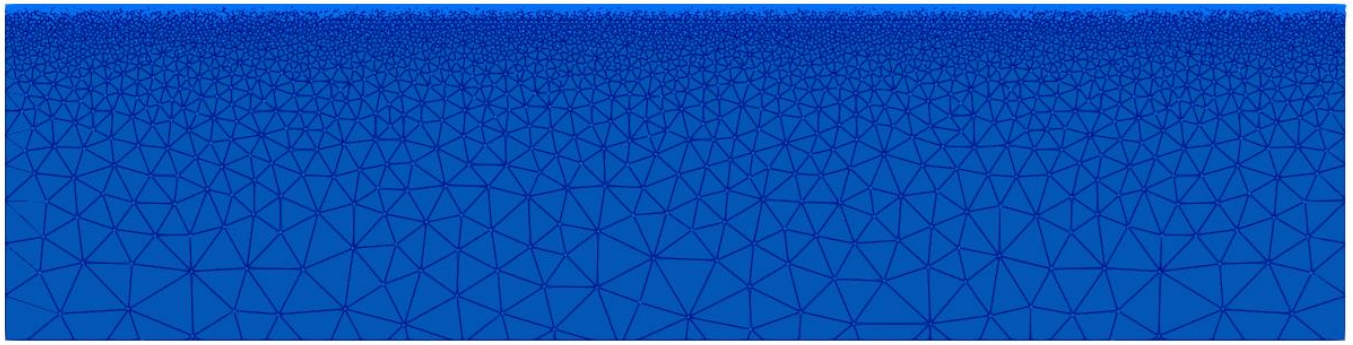
(weakly coupled staggered scheme)

- Boussinesq approximation
- Marangoni effect
- Phase change (flow resistance + latent heat)

Bobach, B. J., Boman, R., Celentano, D., Terrapon, V. E., & Ponthot, J. P. (2021). Simulation of the Marangoni Effect and Phase Change Using the Particle Finite Element Method. *Applied Sciences*, 11(24), 11893.

Examples (1/3) : Laser Melting Simulation

PFEM-AS



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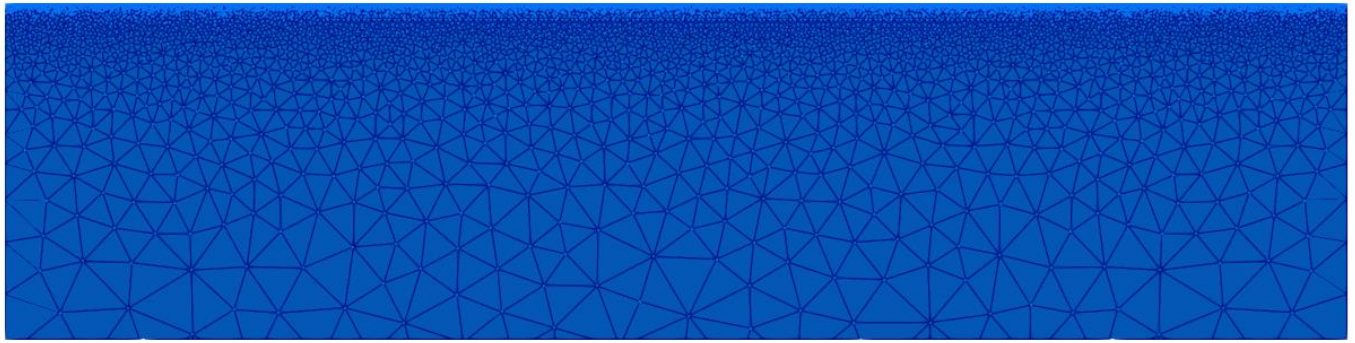

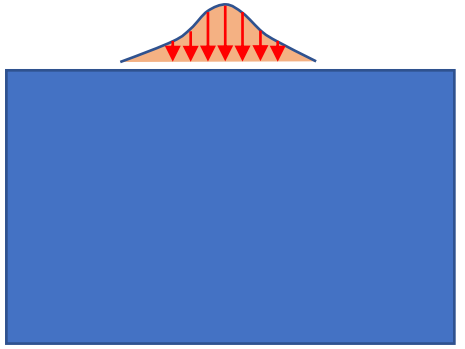

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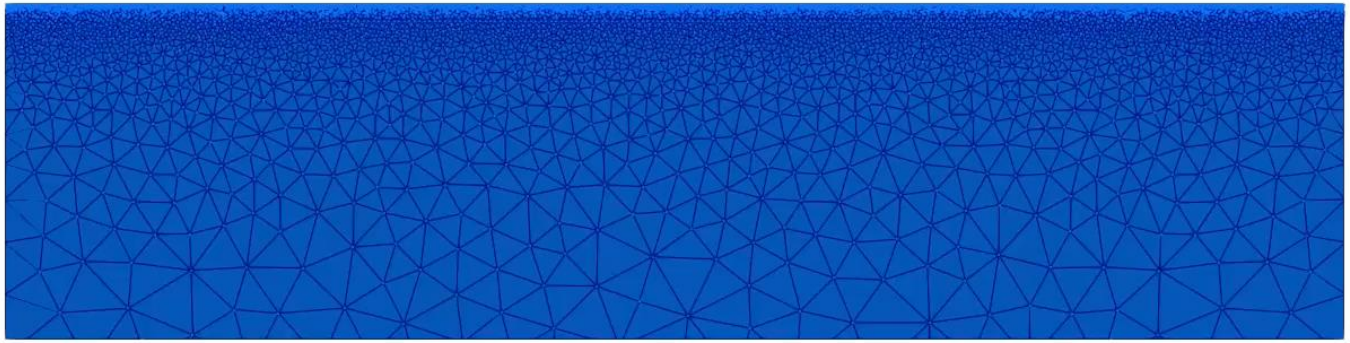

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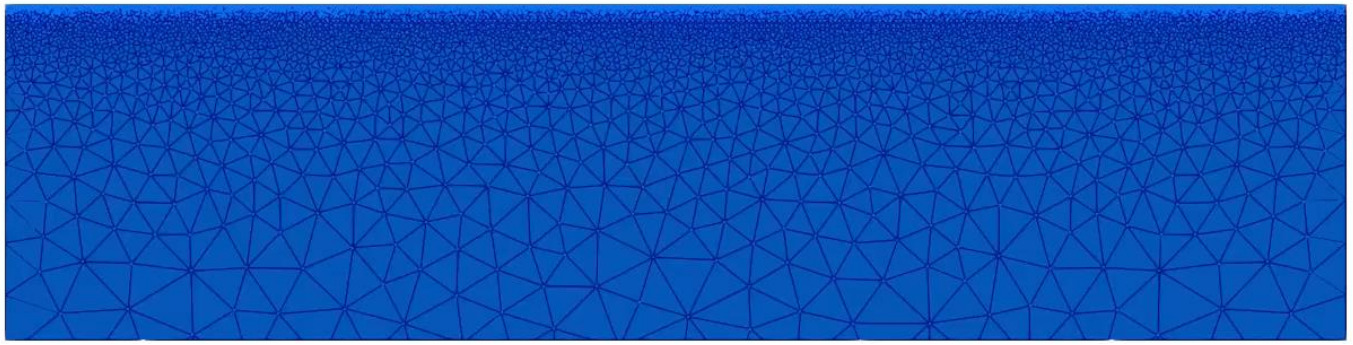

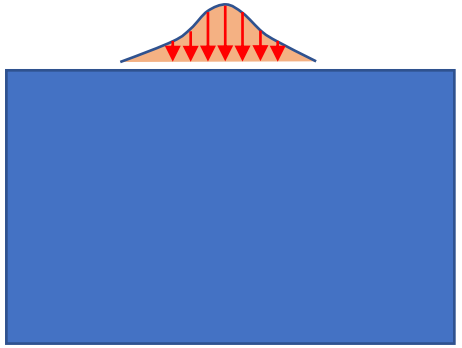

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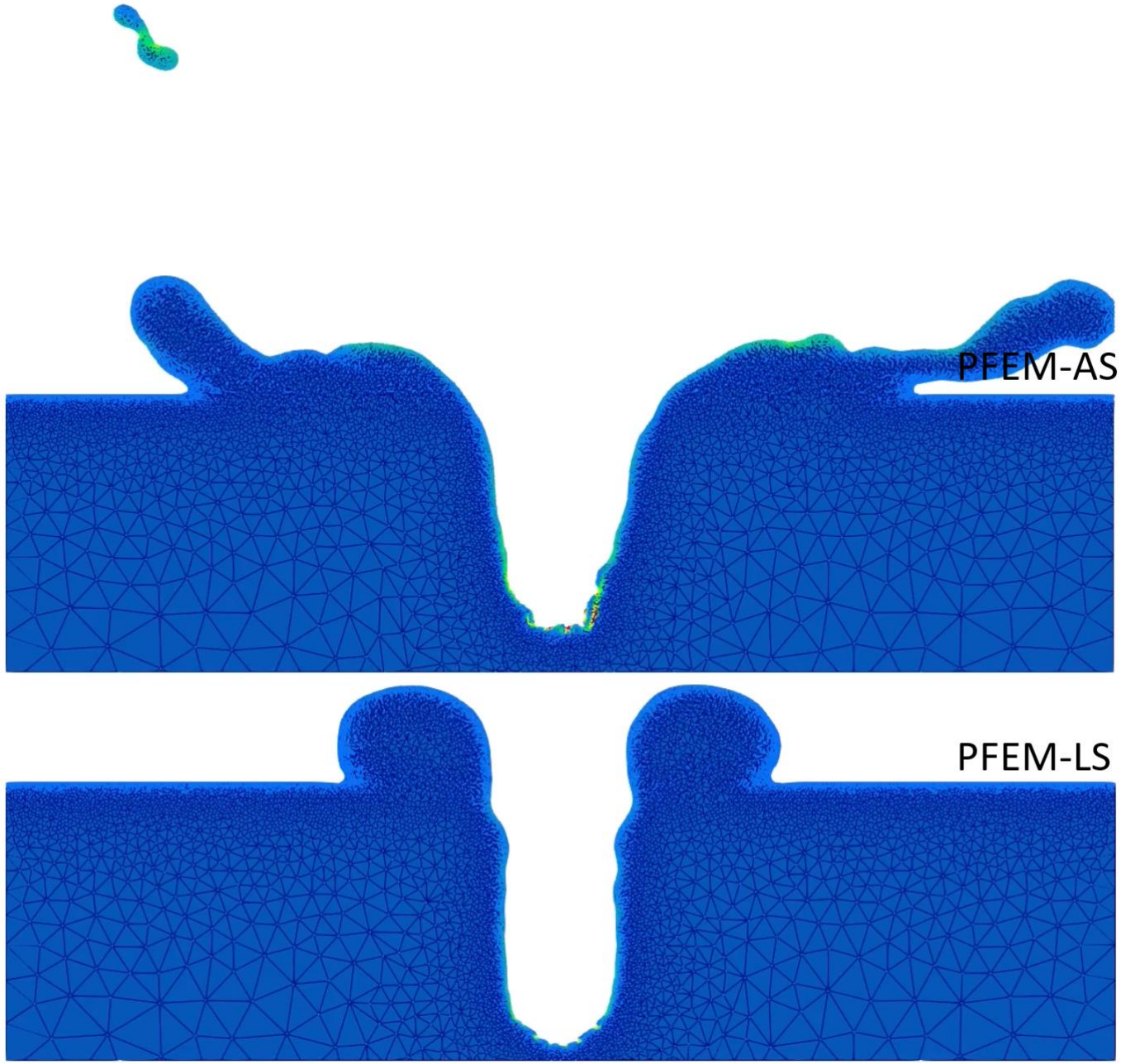

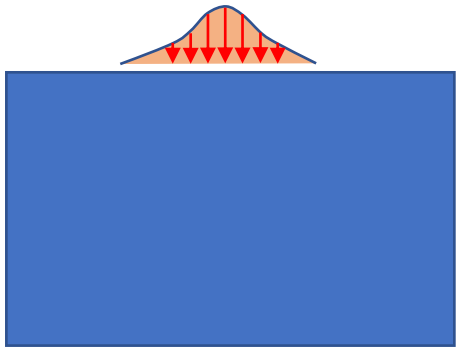

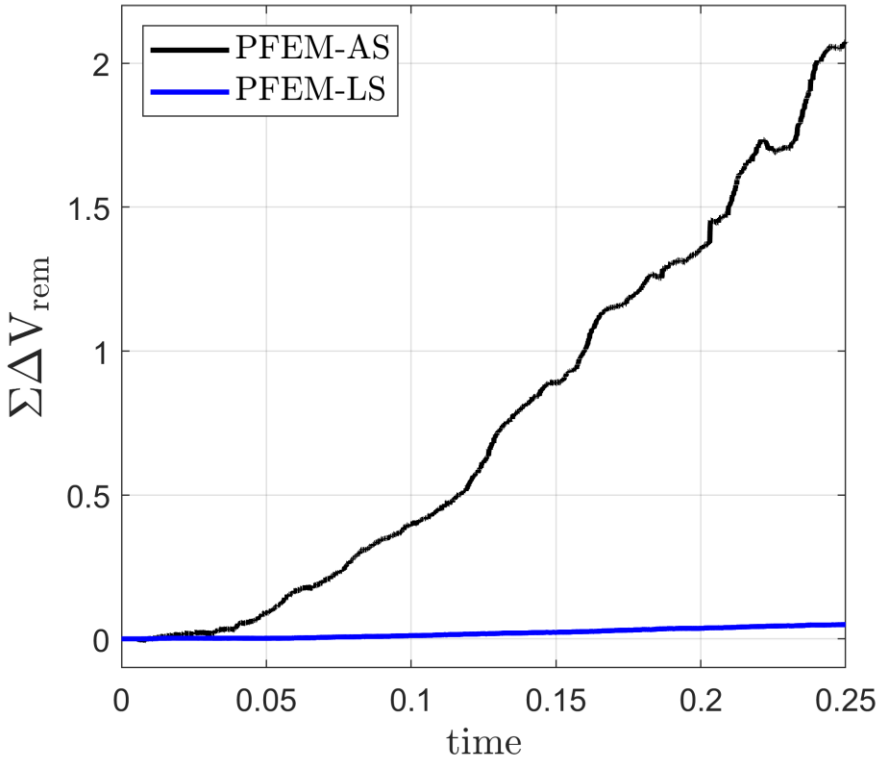

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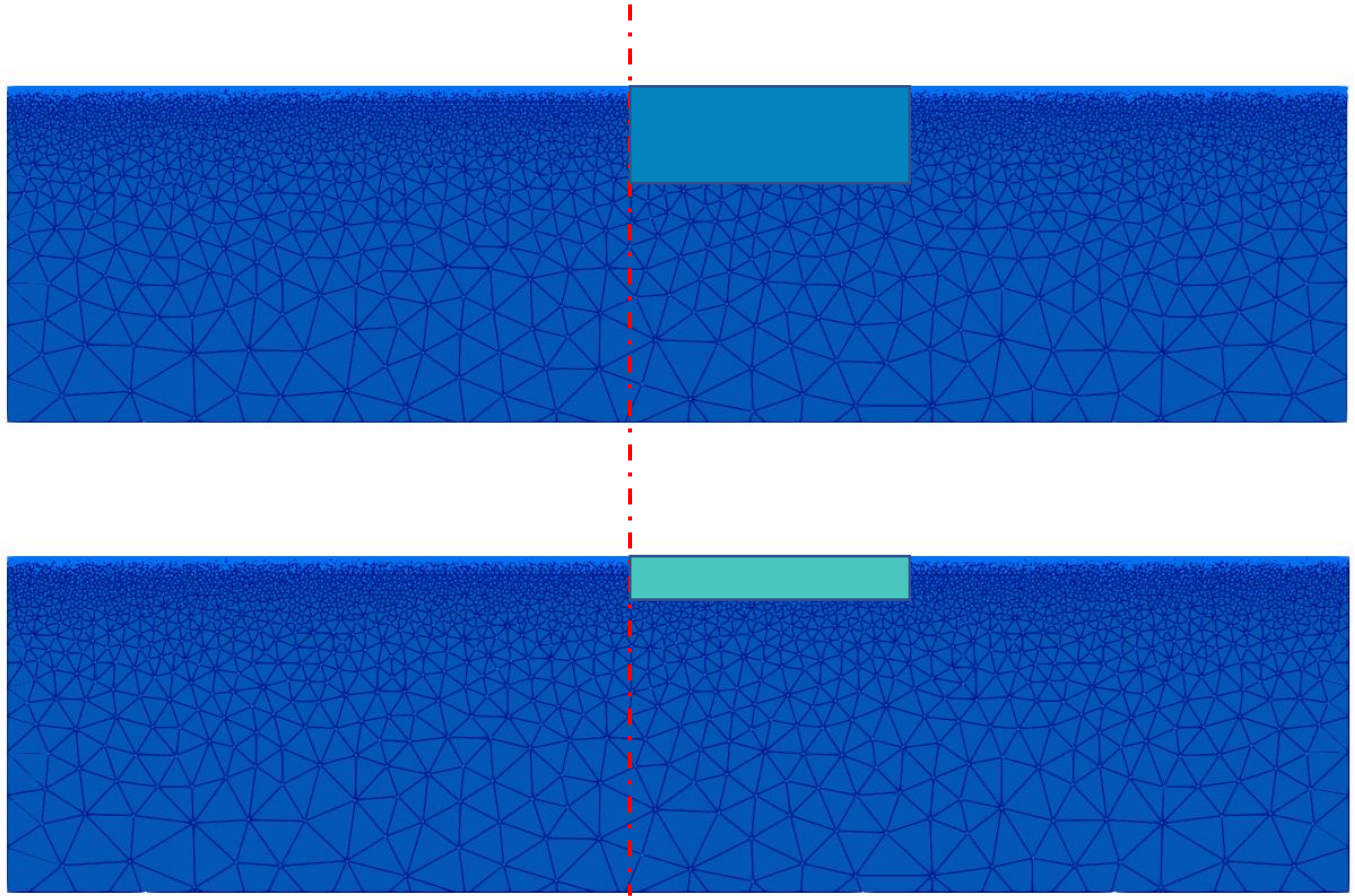

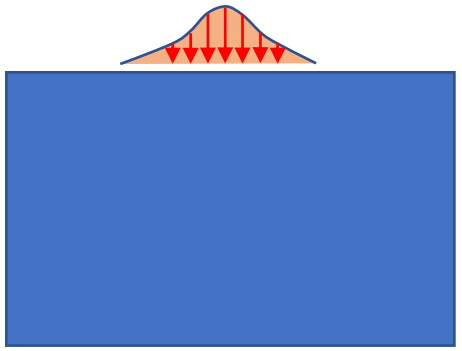

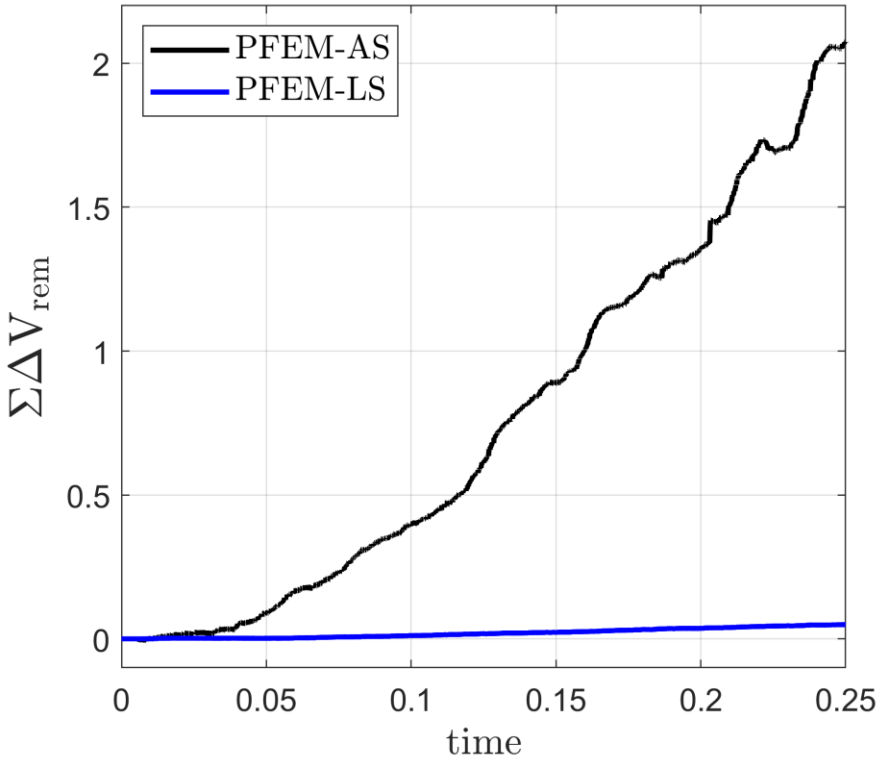

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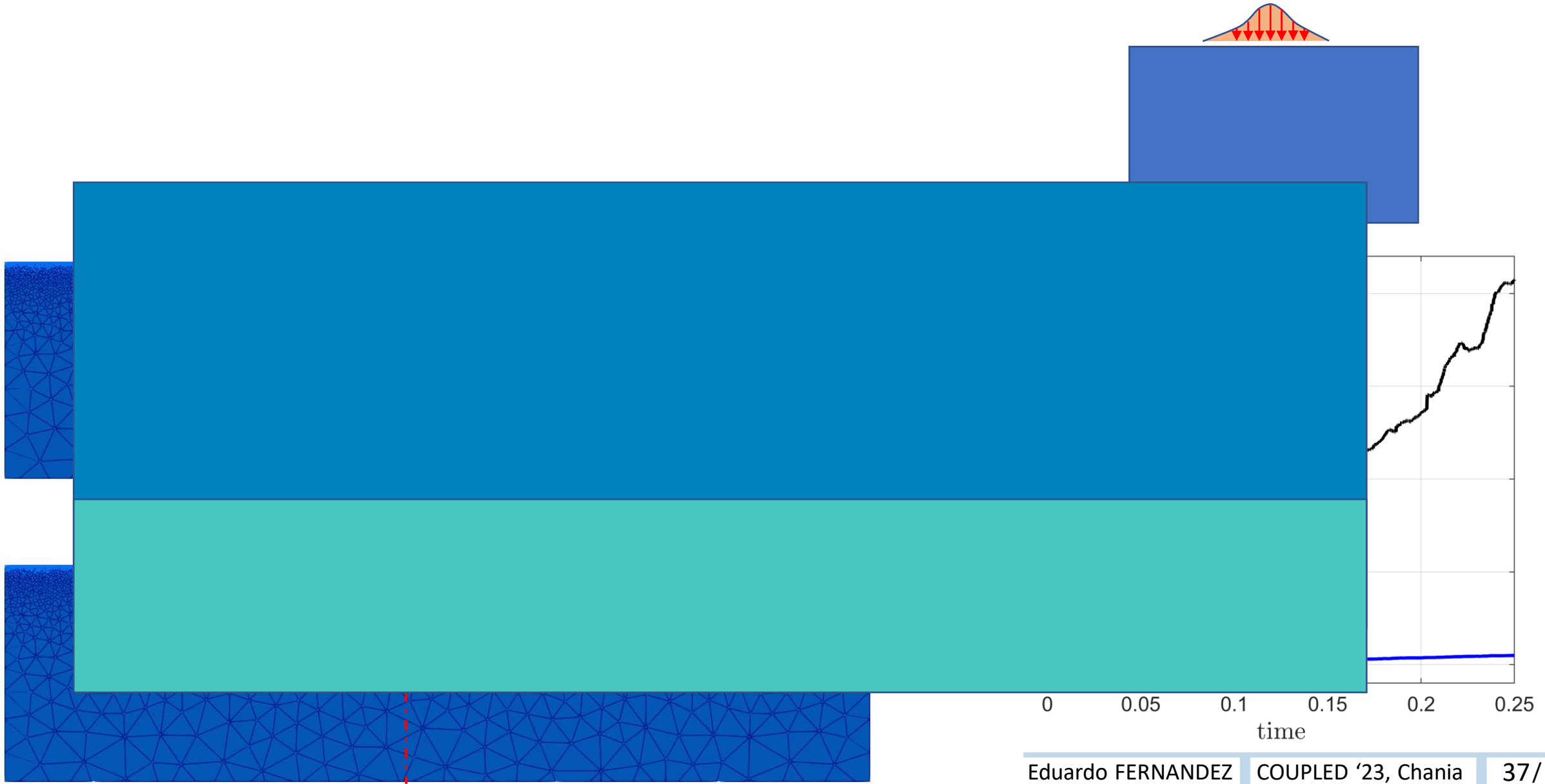

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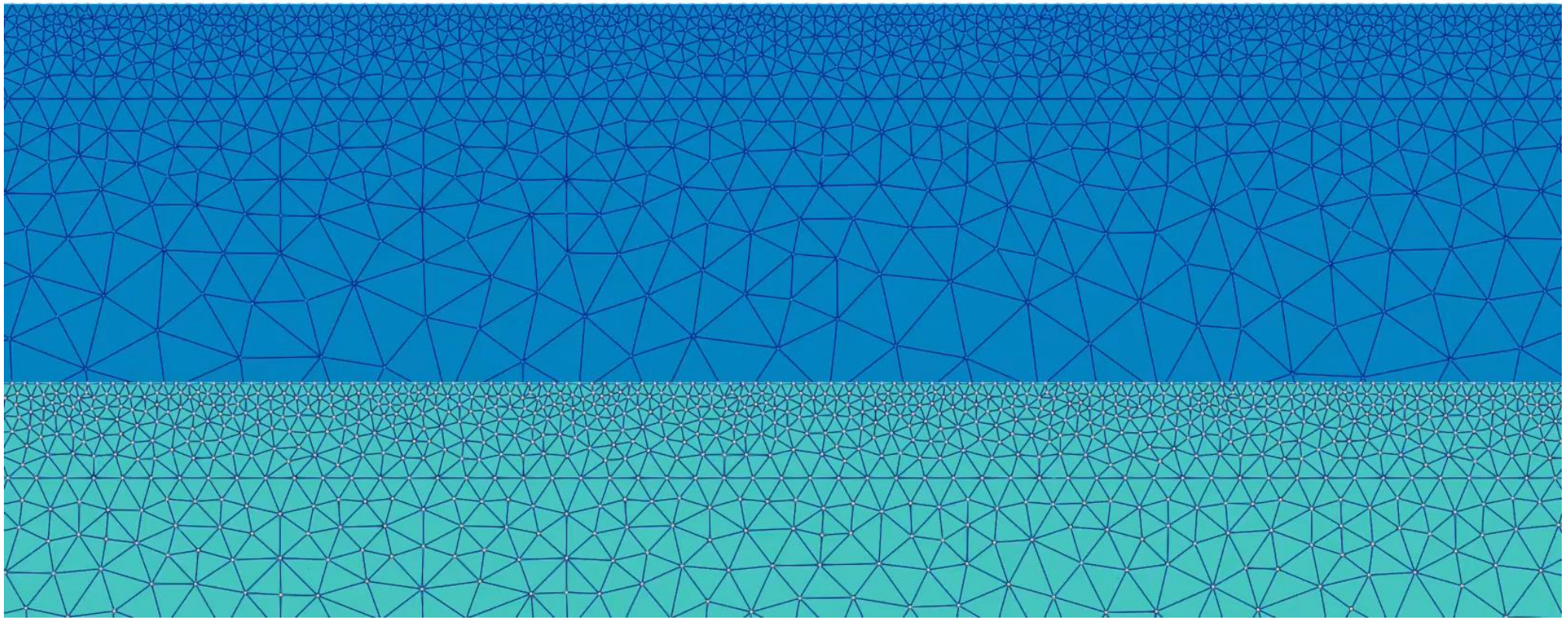

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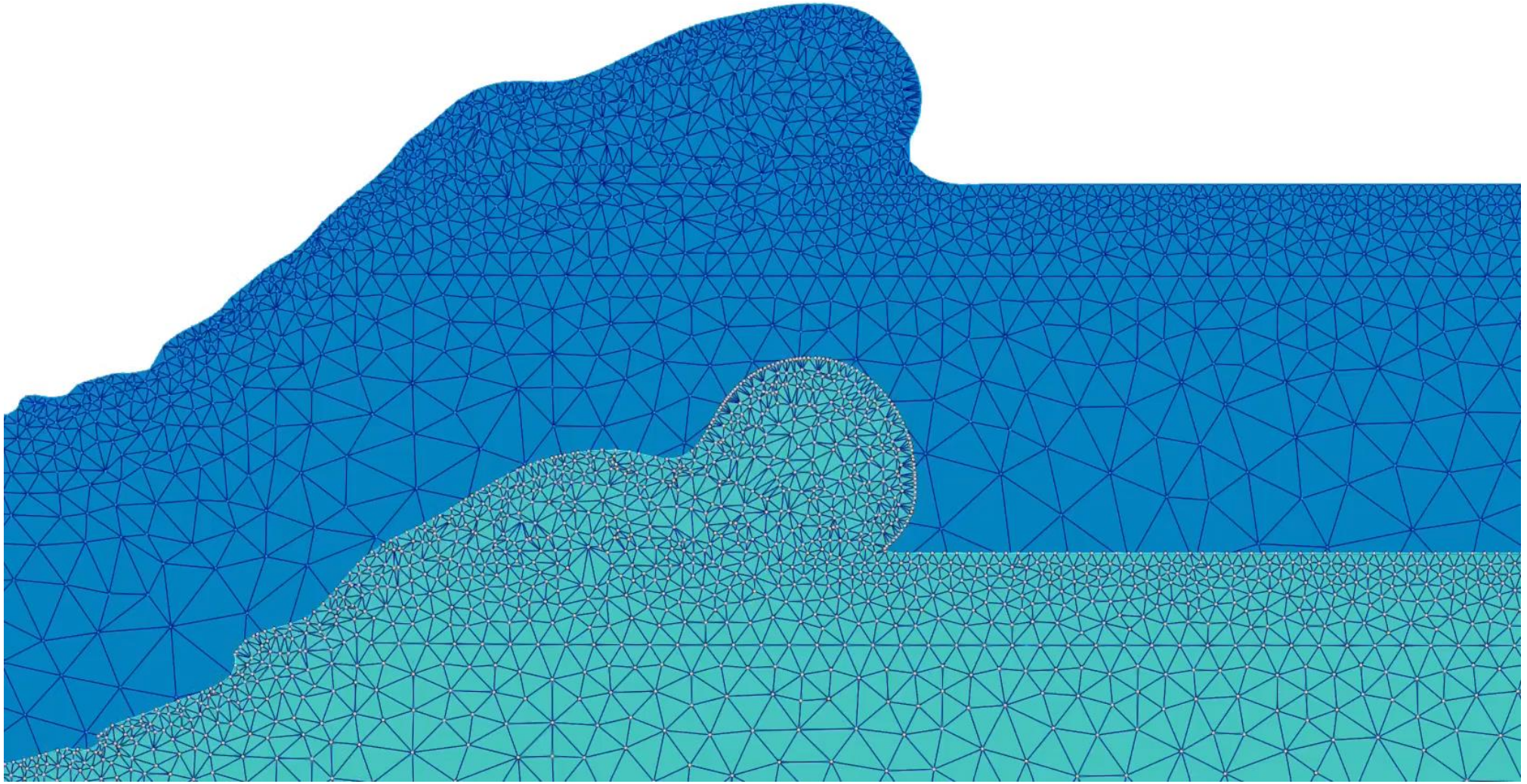

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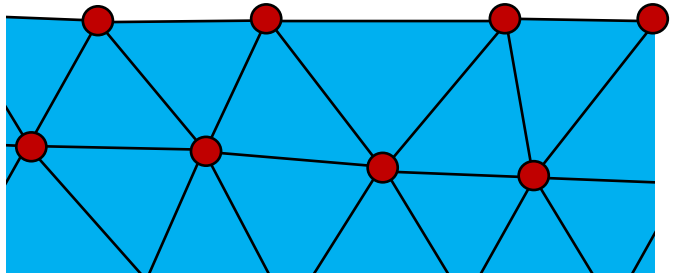

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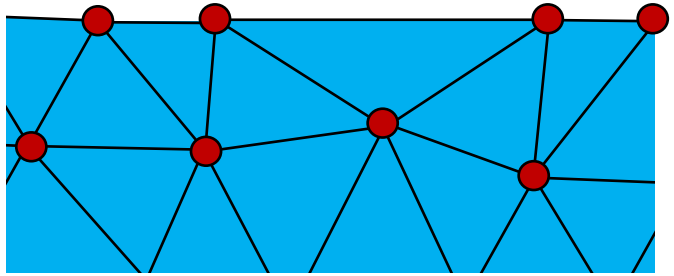

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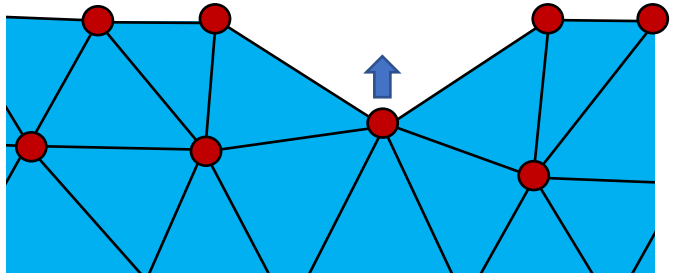
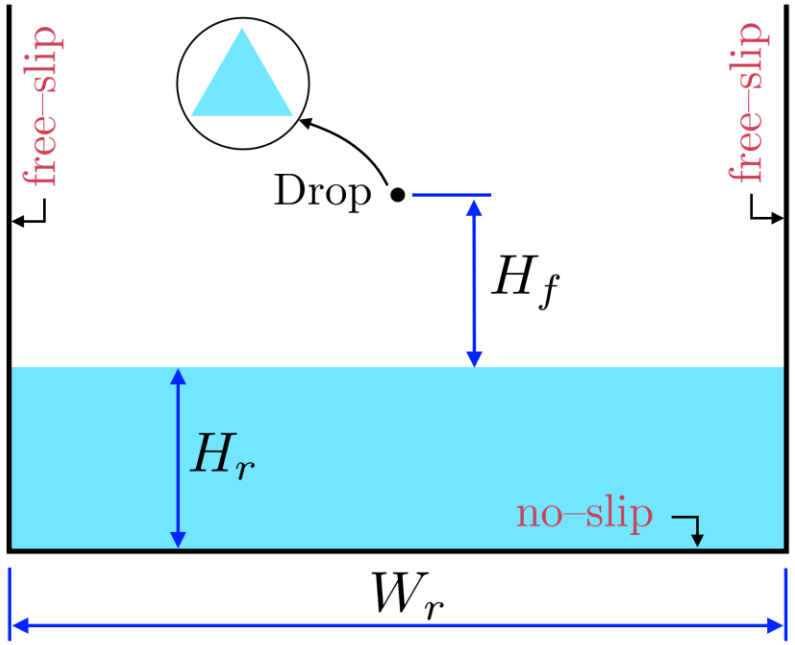
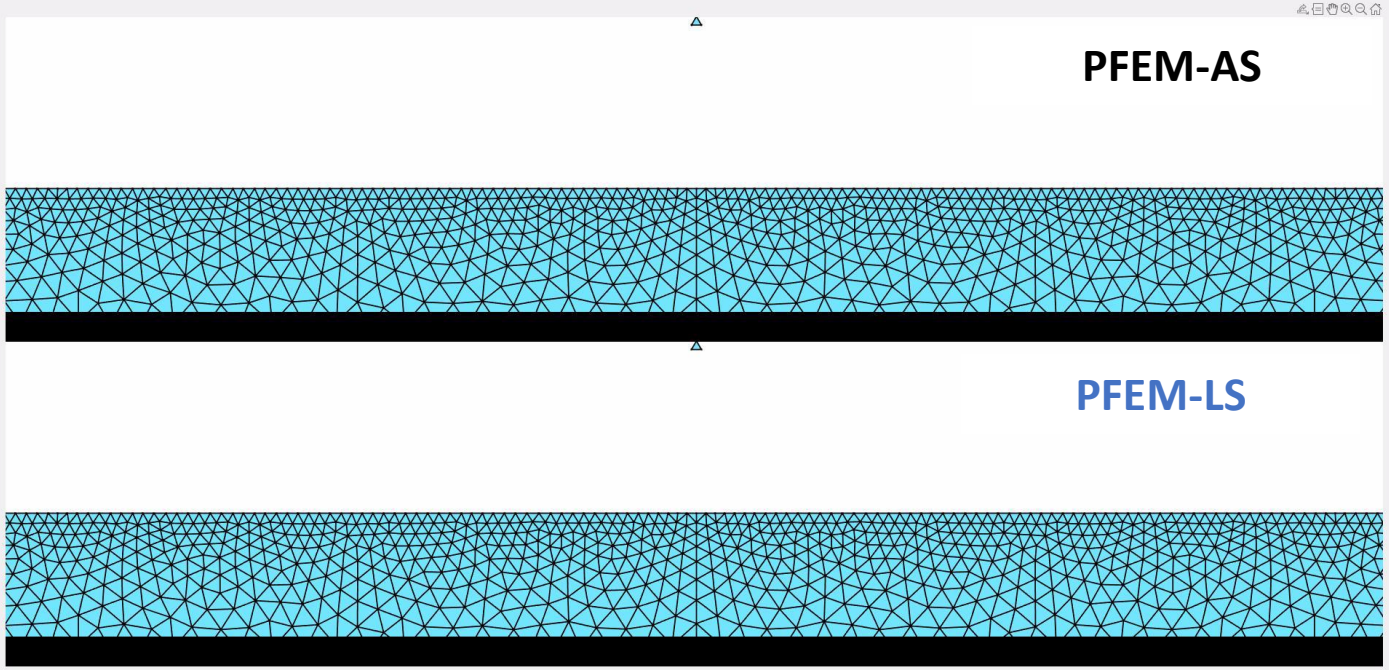


Examples (2/3) : Impact of a coarse drop





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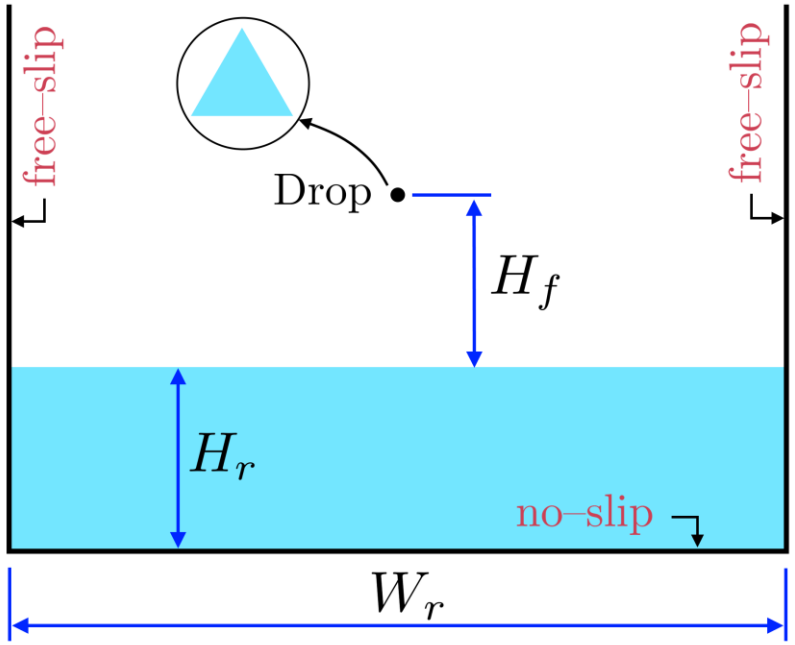
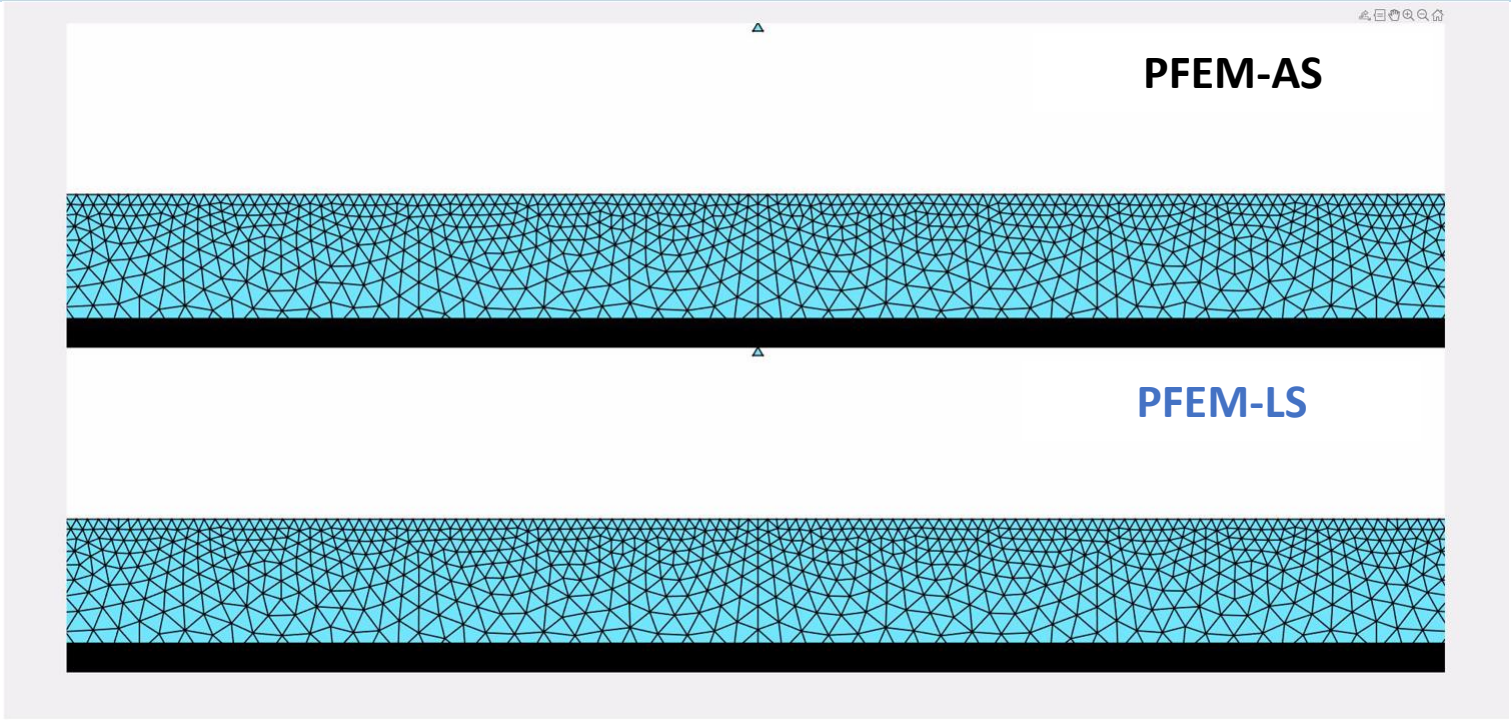
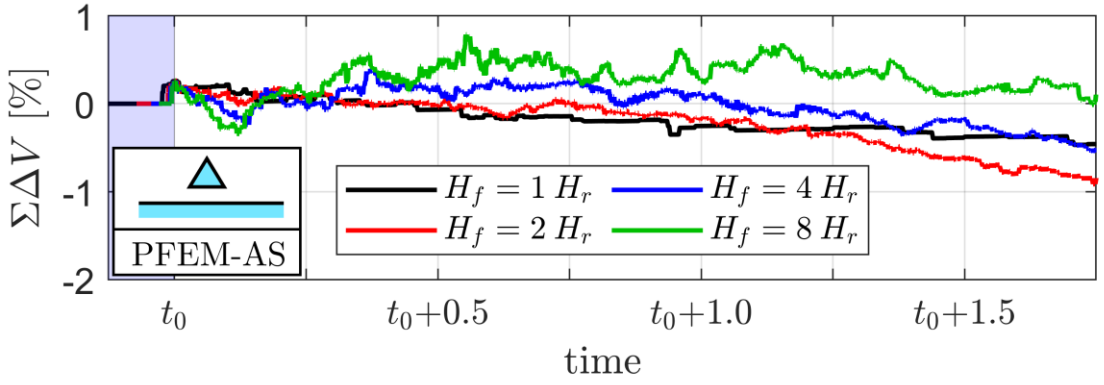
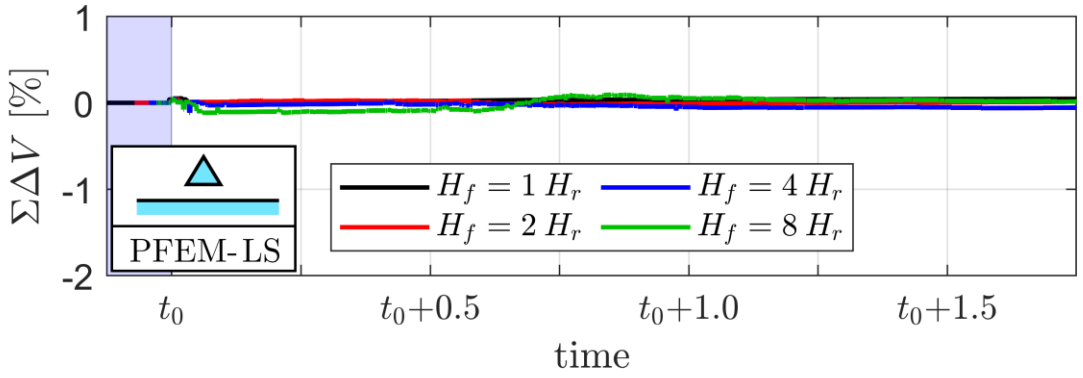
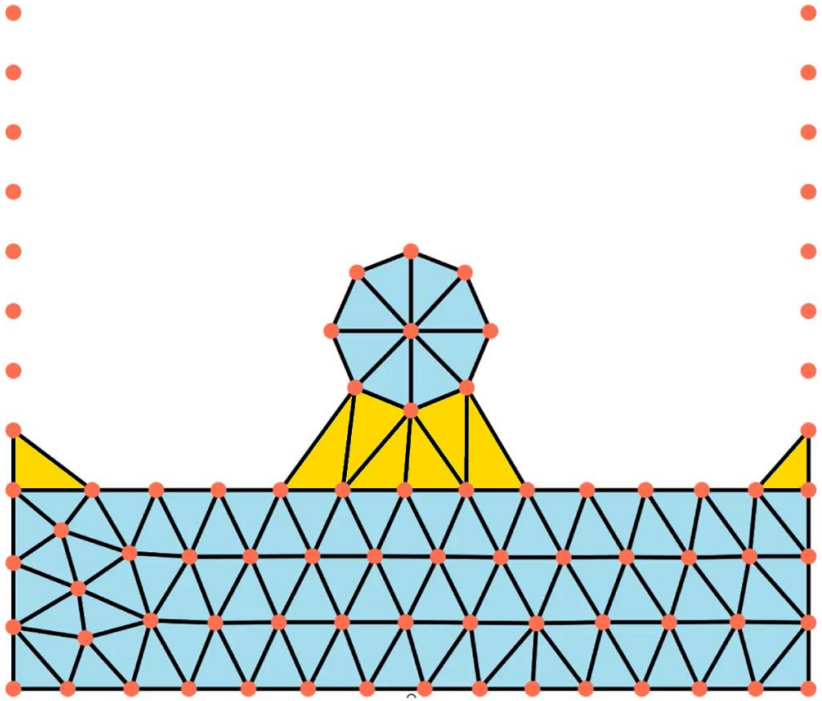


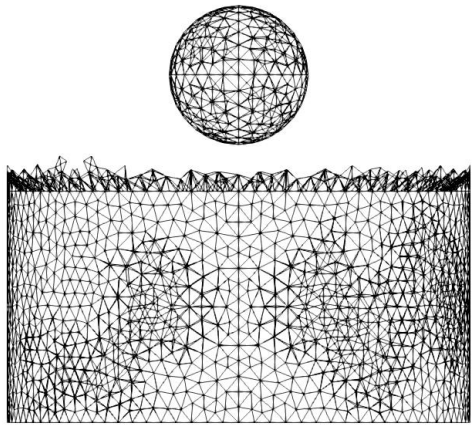


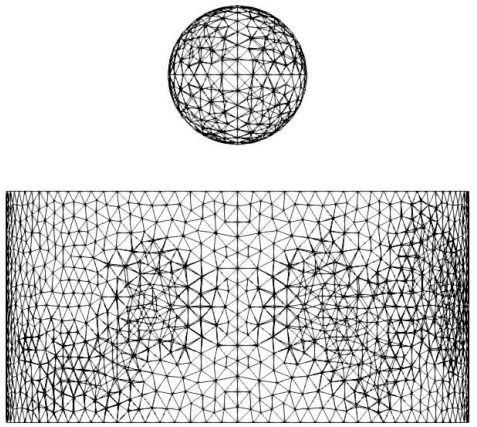


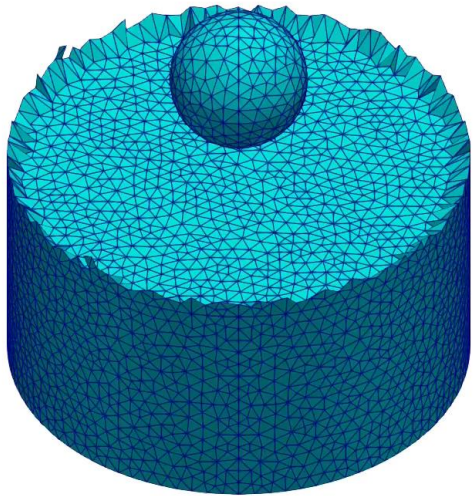


Examples (3/3) : Disk fall in fluid









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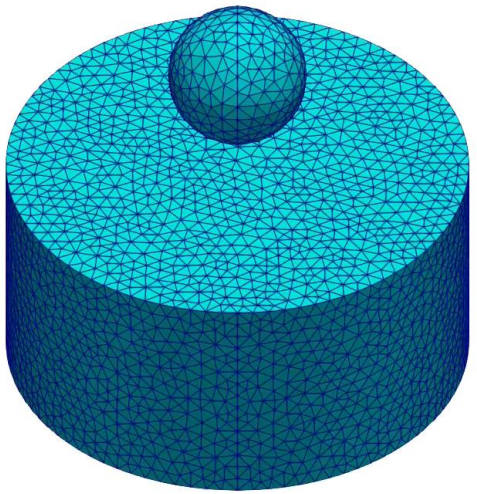

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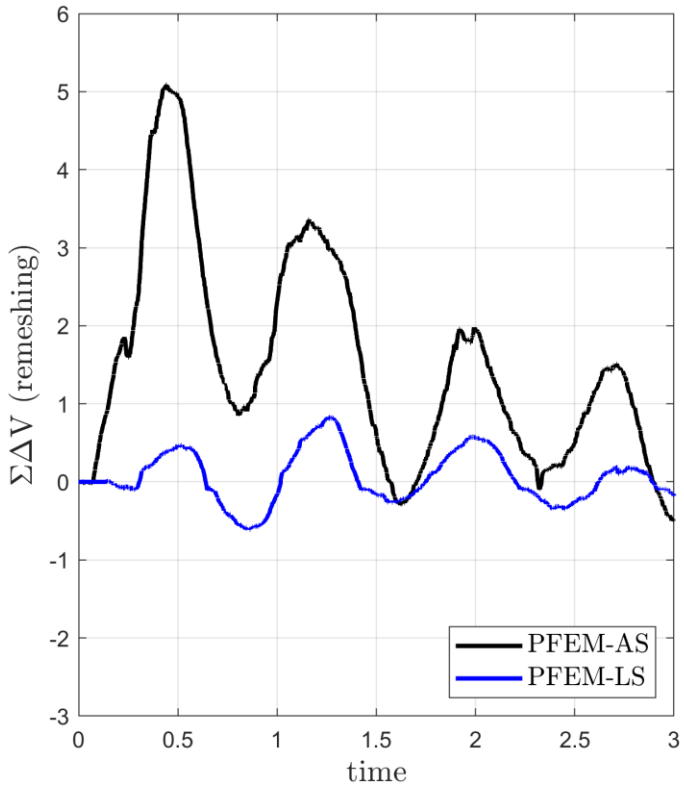

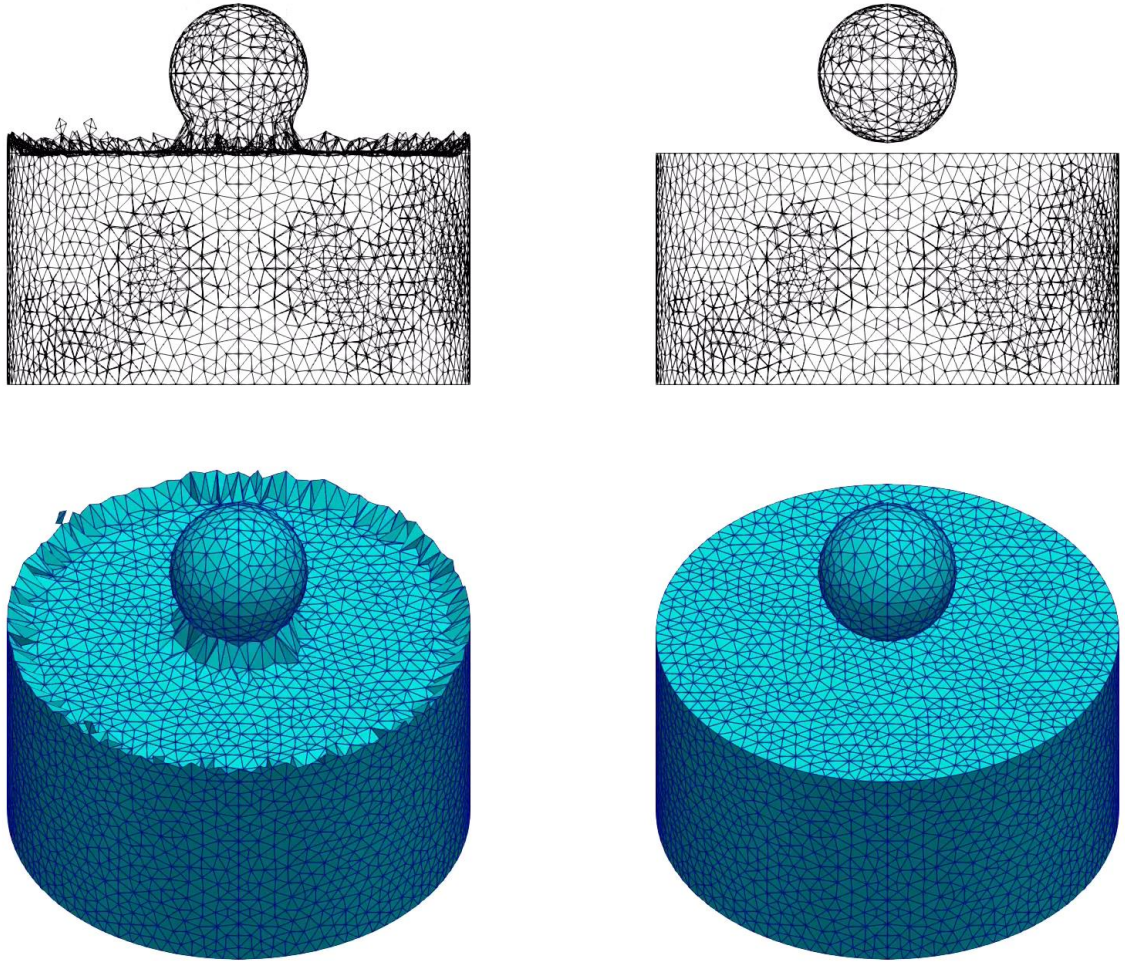

PFEM-AS **PFEM-LS**

University of Liège, Belgium.
Aerospace and Mechanical Engineering Department,
Computational Non-Linear Mechanics Laboratory (LTAS-MN2L)

A new remeshing strategy relying on level-set functions for the Particle Finite Element Method

Eduardo Fernández,
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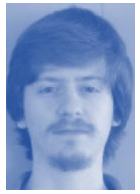
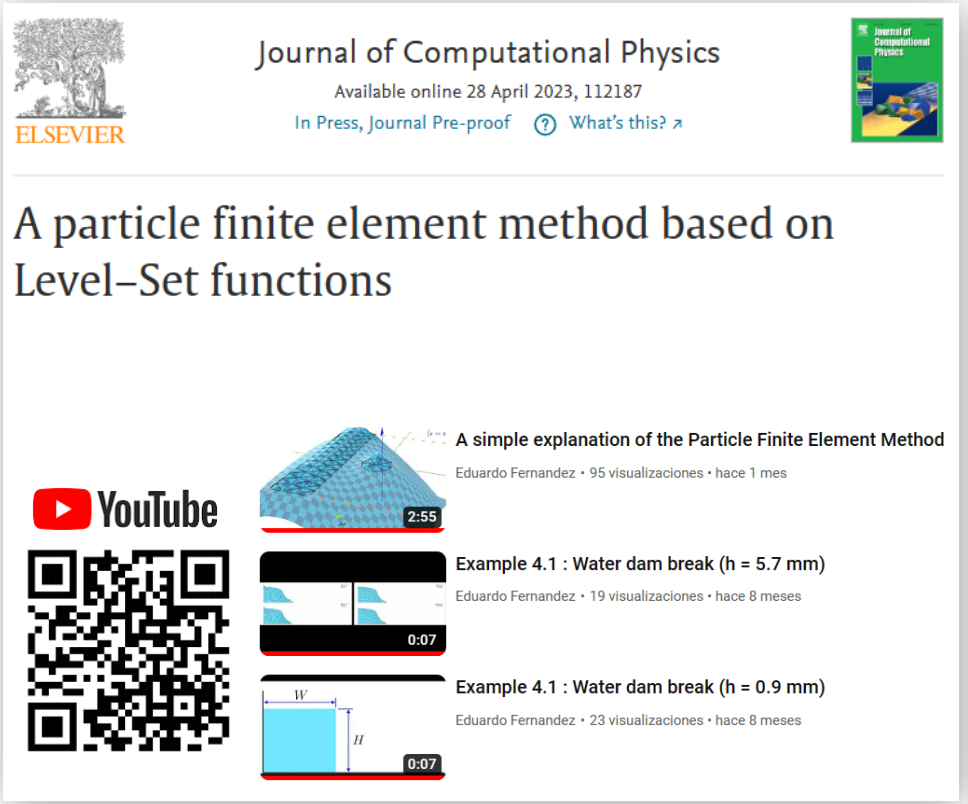



Luc Papeleux,
Romain-Boman,


Jean-Phillipe Ponthot


http://metafor.ltas.ulg.ac.be/



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