The moving-mesh adaptation in 3D. Steady mesh adaptation to the surface of helicopter fuselage.

Speaker: Valeriia Tsvetkova  
*Keldysh Institute of Applied Mathematics of RAS*

*NORMA Progress Meeting, April 20, 2021*
Main features of the technique

• Simply connected domain

• Geometry is defined by interpolation grid (level-set tree)

• Immersed boundary method (IBM) – Brinkman penalization

• The shape of the body is approximated using adaptation of r-type (nodes are redistributed while topology remains the same)

• Adaptation produces anisotropic cells
Features of the adaptation technique

- Level-set function $u(x,t)$ defines the solid body location and is close to signed distance function near the boundary.
- Metric tensor $G(x,t)$ is built upon $u(x,t)$ as

$$G(x, t) = \sigma_1^2 I + (\sigma_2^2 - \sigma_1^2) \nabla_x u \nabla_x u^T \frac{1}{|\nabla_x u|^2} \quad \Rightarrow \quad \sigma_2 = \sigma_1 \quad G(x, t) = \sigma_1^2 I$$

- On highly curved fragments of the boundary or near sharp vertices $\sigma_2 = \sigma_1$, otherwise $\sigma_2 = \sigma_1 / K$. $K$ is user-defined anisotropic ratio.

$\sigma_1 = \sigma_{\text{normal}}(x, t)$ - mesh stretching in the normal direction

$\sigma_2 = \sigma_{\text{tangential}}(x, t)$ ($\sigma_{2,3}$ in 3D) - spatial distribution of the anisotropy
Testing for 3D case

Sphere of size $D = 1$ is making forced harmonic movement along $Oy$ with $f=0.15$, $A=0.2$
$Re=318.8$

Body-fitted mesh
Adapted mesh
Solid domain
Testing for 3D case: comparison in profiles $y=\{-0.25, 0, 0.25\}; x=0; -1<z<1$
Adaptation for ellipsoid (solid part is blanked)
Mesh adaptation to the boundary of the helicopter fuselage

1. Body-fitted mesh

2. Helicopter fuselage geometry

3. Adaptive grid generated for the geometry

4. Solid part of the adapted mesh

5. Adapted unstructured mesh
Automatic anisotropy control
Automatic anisotropy control

Main idea: define $\sigma_2$ on interpolation grid during mesh preparation

Curvature-dependent function in vertices of the contour

Define $\sigma_2$ in the entire domain

Adaptation will use the parameter as a predefined value
Problems to solve

- Improve adaptation to the boundary of the helicopter fuselage (boundary approximation and compression degree)
- Compare results made using body-fitted mesh and adapted mesh