InterDyMFoam coupled with forces and mesh motion in 6-DoF

Erik Ekedahl

Outline

1 Introduction and motivation

2 Theory

3 Algorithm
- Usage
- Possible Alterations

4 Result

5 Discussion and Improvements

Motivation

- Volume-of-Fluid method and dynamic mesh with 6-degrees of freedom
- Marine Applications
- Base:interDyMFoam - Volume of Fluid.

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- Two phases; gas and liquid in this case.
- Interface

$$\gamma = \begin{cases} 1 & \text{if in the water} \\ 0 < \gamma < 1 & \text{in the region around the surface} \\ 0 & \text{if in the air} \end{cases}$$

- Under-relaxation

$$\phi_{new} = \alpha\phi_{new} + (1-\alpha)\phi_{old} \tag{1}$$

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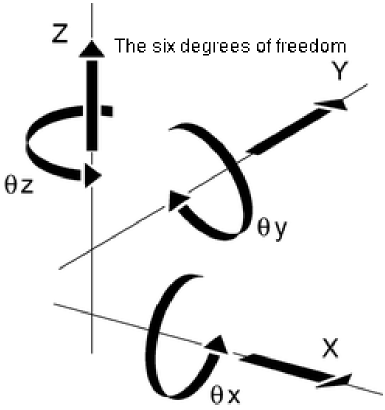
Six Degrees of Freedom



ls

Figure: 6-DOF

Forces and Moments

-
$$\boldsymbol{F} = \int_S \boldsymbol{F}_{ext} + \boldsymbol{F}_{flow} \tag{2}$$
$$\boldsymbol{M} = \int_S \boldsymbol{M}_{ext} + \boldsymbol{M}_{flow} \tag{3}$$
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Rotation and Translation

- *Quaternion* - Hamilton 1843
- Base: $\{1, i, j, k\}$ as $a1 + bi + cj + dk$
- Where a, b,c and d are real numbers and $i^2 = j^2 = k^2 = ijk = -1$
- Composed of one vector and one scalar in OF.
- Euler angles → quaternion and back.

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mesh Deformation

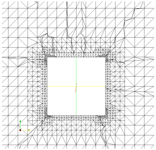

Figure: the *xy*-plane at time 0 seconds

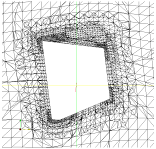

Figure: the *xy*-plane at time 16 seconds

Algorithm

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while Time is running do
    Extract forces and moments from pressure, buoyancy.
    Extract forces and moments from viscous effects.
    Divide by mass for forces and inertia for momentum.
    Extract the acceleration by multiplication of the real time
    interval.
    Reset and move center of gravity.
    Translate patch to origo.
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ForceFoamDict

forceBalance forceBalanceEnabled yes;

/* ———————————————————————— */

// Mass of the moving part //M M [1 0 0 0 0 0 0] 136.51; M M [1 0 0 0 0 0 0] 108000;

// Mass of the moving part inertia inertia [1 2 0 0 0 0 0] 648000;

// Limit the maximum acceleration on the system (Bandwidth limitation) accelLim accelLim [0 1 -2 0 0 0 0] 1.0e-2;

// Acceleration due to gravity g g [0 1 -2 0 0 0 0] 9.81;

// Direction vector of the acceleration due to gravity gVector (0 0 -1);

// Direction vector of the acceleration due to gravity CgCenter (0 0 0);

/* ———————————————————————— */

motionPatches (cube$_r$*egion*0);

Alterations

- Extract the archives.
- *my6DOFFoam*: run wclean then wmake
- *kubtest*: run application with 'my6DOFFoam'

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- Domain - 40 meter kub with 6 meter cube in the origo
- BC's - slip and reflecting walls, movingWallVelocity for the cube
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Result: cube at initial timestep

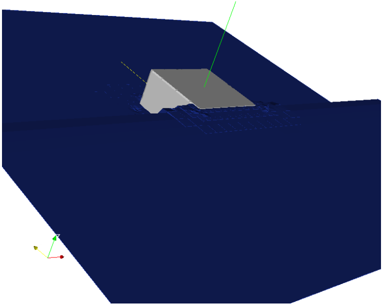

Figure: Time 0

Result: cube is tilted and begining to turn

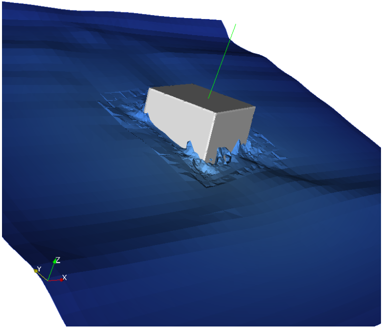

Figure: Time 6 seconds

Result: cube just before divergence

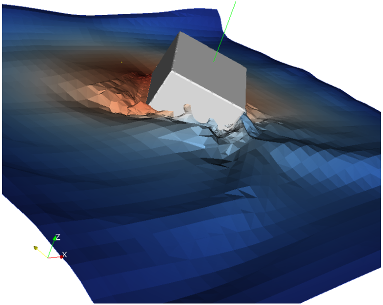

Figure: Time 10 seconds

Discussion

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- Unstable without proper damping
- Skewed cells

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