

Bubbles

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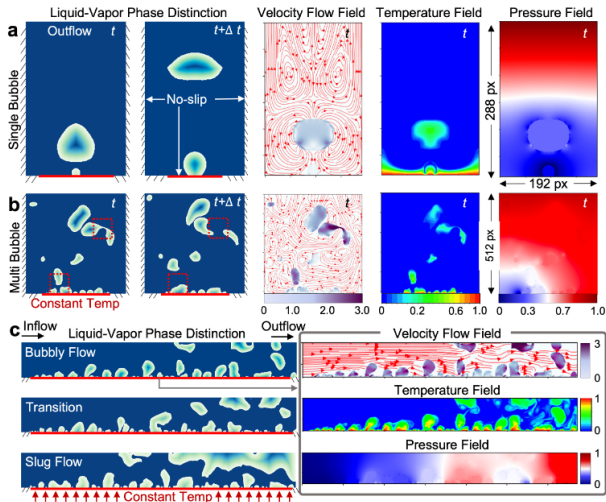
VŠB-TUO

May 2024

BubbleML

- ▶ Dataset
- ▶ Water boiling
 - ▶ Water is heated to 80 degrees or more
 - ▶ Visible water vapor
- ▶ Stationary water (pool) or water moving through a tube
- ▶ Dataset is generated using Flash-X simulator
- ▶ Dataset consists of velocity, bubbles, temperature, pressure
- ▶ Dataset was used e.g. to train optical flow models
- ▶ Paper

Visualized BubbleML dataset



Source

Computational Fluid Dynamics

- ▶ Allows for generation of dataset
- ▶ Bubble movement can be simulated
- ▶ Plethora of paid and free solutions
- ▶ Very difficult to set up

Computational Fluid Dynamics

- ▶ Flash-X
- ▶ OpenFOAM
- ▶ Fluidsim
- ▶ CFD-Tool
- ▶ FluidX3D
- ▶ SPH-EXA
- ▶ Lethe

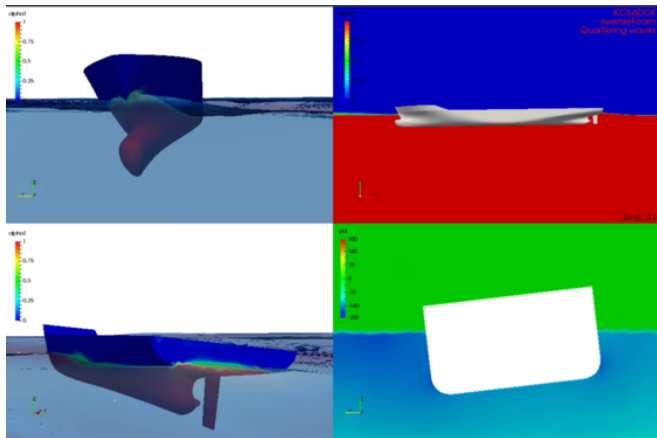
Flash-X

- ▶ Used to generate Bubble ML dataset
- ▶ Open source but requires registration via email to access
 - ▶ Handled very quickly on maintainer side
- ▶ Written in Fortran 90
- ▶ We had trouble building it

OpenFOAM

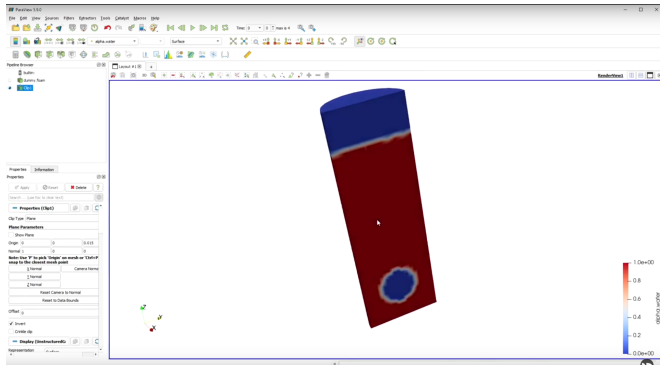
- ▶ Open source
- ▶ Written in C++
- ▶ Naval Hydro Pack can simulate open seas
- ▶ Bubble rising simulation
- ▶ Widely used, often recommended
- ▶ Custom configuration language
- ▶ Output is text files, one per simulation frame
- ▶ Python wrapper to setup simulations (PyFoamSetup)
- ▶ Seems like the best option when it comes to CFD
- ▶ Very difficult to learn

Naval Hydro Pack



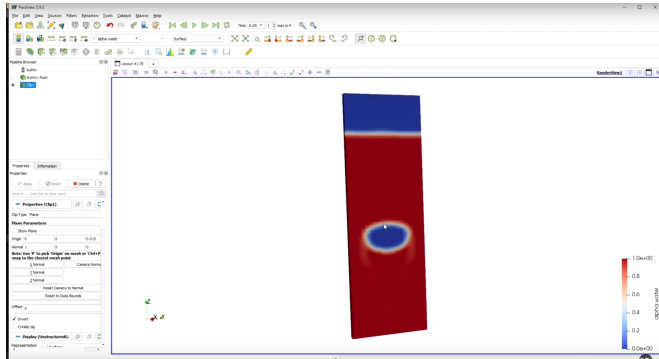
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Bubble Rising



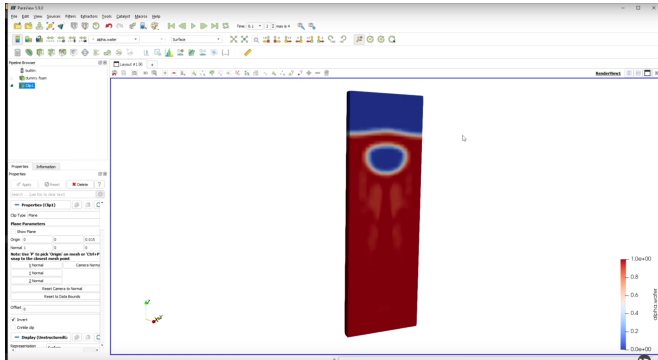
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Bubble Rising



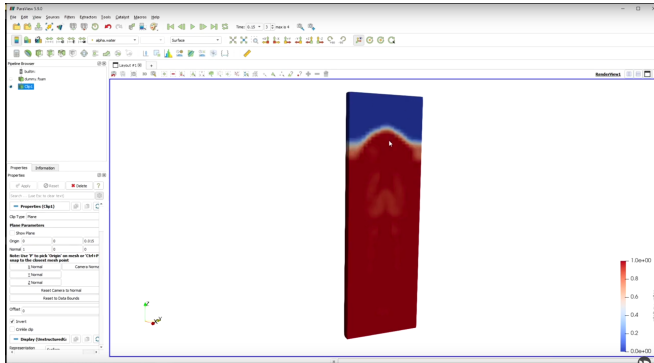
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Bubble Rising



Source

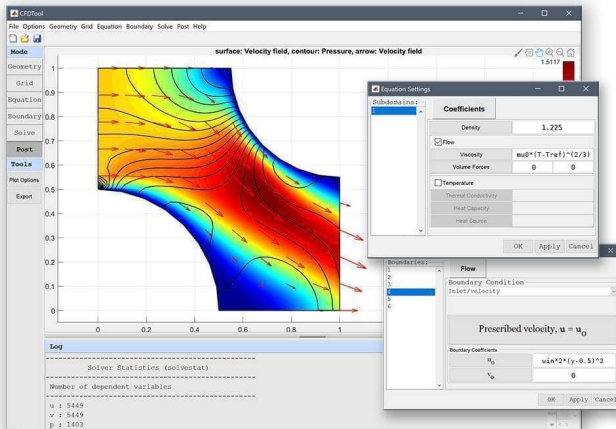
Bubble Rising



Source

CFDTool

- ▶ Matlab toolbox
- ▶ Commercial project
- ▶ Can use multiple CFD solvers
- ▶ Includes OpenFOAM integration



Bubble velocimetry using the conventional and CNN-based optical flow algorithms

- ▶ Claims there are no suitable datasets
- ▶ Images in this paper are generated
 - ▶ Bubbles move randomly
 - ▶ May not change shape
- ▶ CNNs used to detect bubbles
- ▶ Predicts bubble velocity
- ▶ CNN-based model (PWC-Net)
- ▶ Lucas-Kanade and Farnebäck methods
- ▶ Paper

Deep learning-based automated and universal bubble detection and mask extraction in complex two-phase flows.

- ▶ Referenced by the previous paper
- ▶ Promises to detect up to 95% of all bubbles
- ▶ Detection software is FOSS and [available on Github](#)
- ▶ [Paper](#)

BubbleML

- ▶ Model pretrained on flying chairs
- ▶ RAFT and GMFlow
- ▶ Suggest physics-informed models should be used
- ▶ Bubbles change shape and thus are difficult to track
- ▶ [Github repository](#) contains examples of BubbleML usage