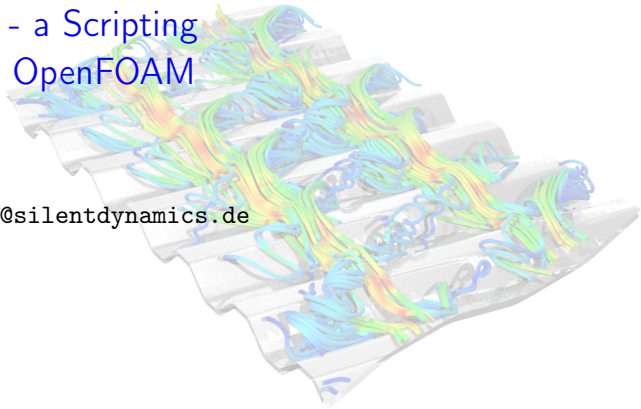


silentdynamics

InsightCAE - a Scripting Toolbox for OpenFOAM

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Motivation

| InsightCAE

| Analysis Examples

| Summary

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InsightCAE

Analysis Examples

Summary

What InsightCAE is about

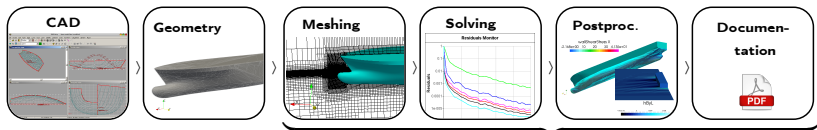
Motivation

InsightCAE

Analysis Examples

Summary

Common practice: *manual* analysis workflow:



- ▶ labour consuming
- ▶ potentially complicated, error prone

InsightCAE: *automated* workflow:



Using CAE (CFD and/or FEM) productively for design tasks

- ▶ involves repeated analysis of numerous similar variants
 - ▶ quick and efficient, with minimum pre/post processing effort
 - ▶ accurate, following a best-practice
 - ▶ safe, without need to repeat things because of user errors!
- ▶ a thorough documentation of every analysis is needed
 - ▶ to review trends
 - ▶ backtrace errors

Using open source CAE software productively

- ▶ OSS often has open architecture with many possibilities for automation
- ▶ many independent software tools for similar tasks are available but with different strengths and weaknesses
 - ▶ need to combine and support multiple tools
 - ▶ one quickly ends up in complicated workflows
- ▶ ⇒ automation can hide complexity of the workflow

What is the idea/aim of “InsightCAE”?

- ▶ Conduct an “analysis” as much automated as possible



- ▶ Take a minimum of necessary parameters, include documentation of the parameters
- ▶ Implement a best practice for a given analysis/task
- ▶ Bundle addons, extensions and interfaces for all required external software utilities
- ▶ Deployment: provide installation package for all workflow-related software components

Applications in mind

- ▶ Design computations
 - ▶ manual investigation of many variants
- ▶ Optimization
 - ▶ automatic computation of many variants, e.g. by DAKOTA
- ▶ Quality control
 - ▶ implementation of testsuites and a standardized way for performing certain analyses

1. Shell scripts

- ▶ Pro: simple, next logical step after command line
- ▶ Con: limited, even floating point arithmetics is a mess

2. Python scripts

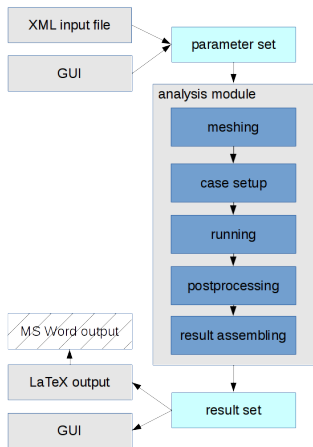
- ▶ Pro: scalable, much freedom
- ▶ Con: if project grows large: very difficult to debug and maintain

3. C++ project

- ▶ Pro: mature, all possibilities, best maintainability
- ▶ Con: programming skills, more boilerplate in project setup

⇒ InsightCAE is written in C++

⇒ with python wrappers



Here: simple CFD workflow
meshing > case setup > running

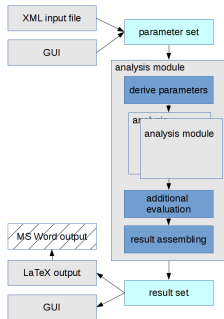
- ▶ basic entity: analysis module
 - ▶ contains problem specific algorithms
 - ▶ currently written in C++,
 - ▶ optionally python

What is an “analysis”?

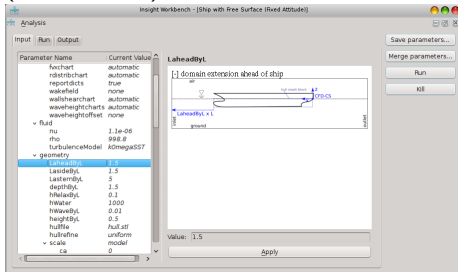
Can be:

- ▶ CFD simulation
- ▶ simple algebraic calculation
- ▶ call other analysis modules: e.g. parametric study

⇒ Is not restricted to FEM/CFD!



- ▶ GUI for editing parameters / run analyses / preview results (“workbench”)



Parameters Documentation / Help

- ▶ Alternative: Command line tool to perform analyses (“analyze”)
`$> analyze --double LaheadByL:2.3 inputfile.ist`

▶ CAD module

- ▶ emphasis on model processing
⇒import model from any source
- ▶ based on OpenCASCADE, import of IGES, STEP, BREP
- ▶ models are described by scripts
- ▶ graphical interpreter for scripts ("iscad")
- ▶ more features:
 - ▶ entity selection by filtering commands, e.g.
`inlet=model.faces('isPlane && min(faceCoG.x)')`
 - ▶ meshing (through gmsh)
 - ▶ fully parametric parts, constraint-based sketches, assemblies, part library, drawing export (DXF)

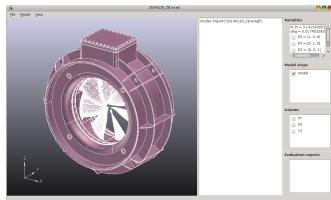


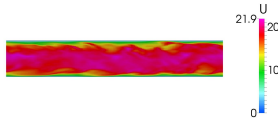
Figure: screenshot of "iscad"

- ▶ in “toolkit”:
 - ▶ Execution of OpenFOAM commands through batch systems
 - ▶ When generating case setups, differences for multiple OpenFOAM version is accounted for (1.6-ext, 2.1, 2.2, 2.3)
 - ▶ Reasonable default solver settings for a number of solvers
 - ▶ Dictionary parser
- ▶ direct additions for OpenFOAM are included as well:
 - ▶ FEMDisplacement-BC for (steady) FSI with Code_Aster
 - ▶ additional discretization schemes
 - ▶ localized limited schemes for interpolation, gradient and sn-gradient
 - ▶ additional tools for post processing
 - ▶ additional BCs: inflowGenerator for LES/DNS

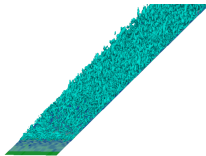
- ▶ in “toolkit”:
 - ▶ Generation of export-files
- ▶ direct additions (python modules):
 - ▶ other side of FEMDisplacement-BC for (steady) FSI with OpenFOAM
 - ▶ functions for analysis of bolted joints with bar elements and contact
 - ▶ through “iscad”: geometry handling, feature selection and meshing using Gmsh

- ▶ simple generic analysis modules for validation (“modules”)

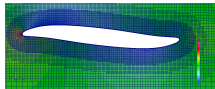
- ▶ channel flow



- ▶ flat plate



- ▶ 2D airfoil

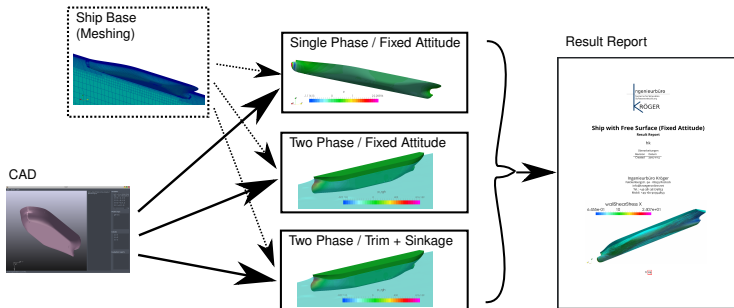


- ▶ ...

- ▶ Addons are loadable containers for specific analysis modules.
- ▶ They need to be created for the specific problem under consideration
- ▶ Available so far:

Ship resistance analysis

- ▶ CFD (OpenFOAM) of ship resistance
 - ▶ single phase (simpleFoam)
 - ▶ single phase with free surface (potentialFreeSurfaceFoam)
 - ▶ two phase (interFoam or LTSInterFoam)
 - ▶ two phase with trim and sinkage (LTSInterDyMFoam)

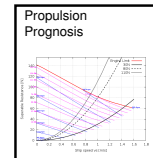
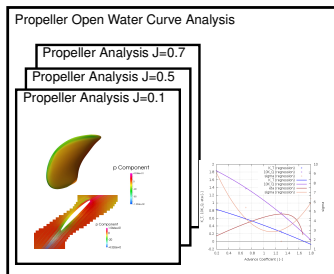
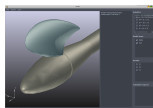


- ▶ inheritance: meshing is (almost) the same for all analyses
- ▶ minimum parameters:
 - ▶ geometry of domain can be computed from given STL geometry
 - ▶ single parameter for resolution n_{ax}
 - ▶ BL thickness is estimated, y^+ is set accordingly

Marine propeller and propulsion analysis

- ▶ CFD (OpenFOAM) of single operation points and open-water curves (meta analysis)
 - ▶ free propeller
 - ▶ ducted propeller
 - ▶ axial pump
 - ▶ optimal diameter, optimal rpm, propulsion prognosis

CAD



Hydrodynamic bearing analysis

- ▶ CFD (OpenFOAM) of hydrodynamic bearings, single excentricity or characteristic curve/field (meta analysis)
 - ▶ circular journal bearing
 - ▶ multi-segment journal bearing
 - ▶ multi-segment journal bearing with fluid-structure interaction (Code_Aster)

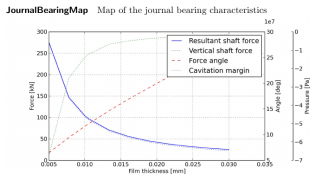
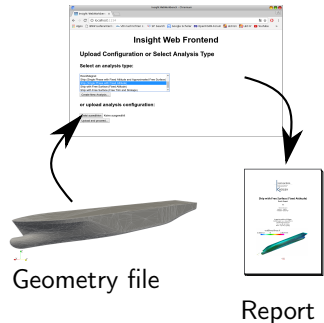


Figure: Journal bearing characteristic map

- ▶ WiP: Web-Frontend (“web-workbench”) for usage e.g. in on-premise clouds
- ▶ Integration in graphical programming language (DICE?)
- ▶ Windows version of Workbench (Remote execution of external tools on linux machine or cluster)



- ▶ InsightCAE shall
 - ▶ be an automation framework for analysis tasks,
 - ▶ connect multiple necessary tools,
 - ▶ encapsulate complicated workflows,
 - ▶ thus help reducing errors
 - ▶ and increase quality of daily work

Thank you for your attention!

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<http://silentdynamics.de>

<http://sourceforge.net/projects/insightcae>