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HANDLING TESSELLATED FREE SHAPE OBJECTS WITH A MORPHING MESH PROCEDURE IN COMSOL MULTIPHYSICS®

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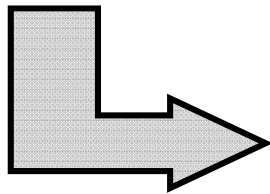
Univ. of Molise
School of Engineering - Italy

Outline

- Introduction and Aims
- Morphing Mesh Approach
- Matlab[®] GUI
 - ✓ Comsol[®]-Matlab[®] interface
- Case Studies
- Final Remarks

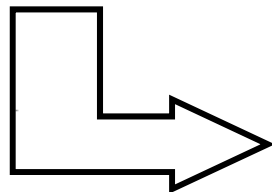
Introduction and Aims

- ❑ **Tessellated mesh** model commonly used in Reverse Engineering applications, Digital Replication for Rapid Prototyping, Computer Graphics
- ❑ In some cases, mesh model can be used as it is,
... instead, in several other applications, it needs to be post-processed



Geometry reconstruction is a very time consuming task

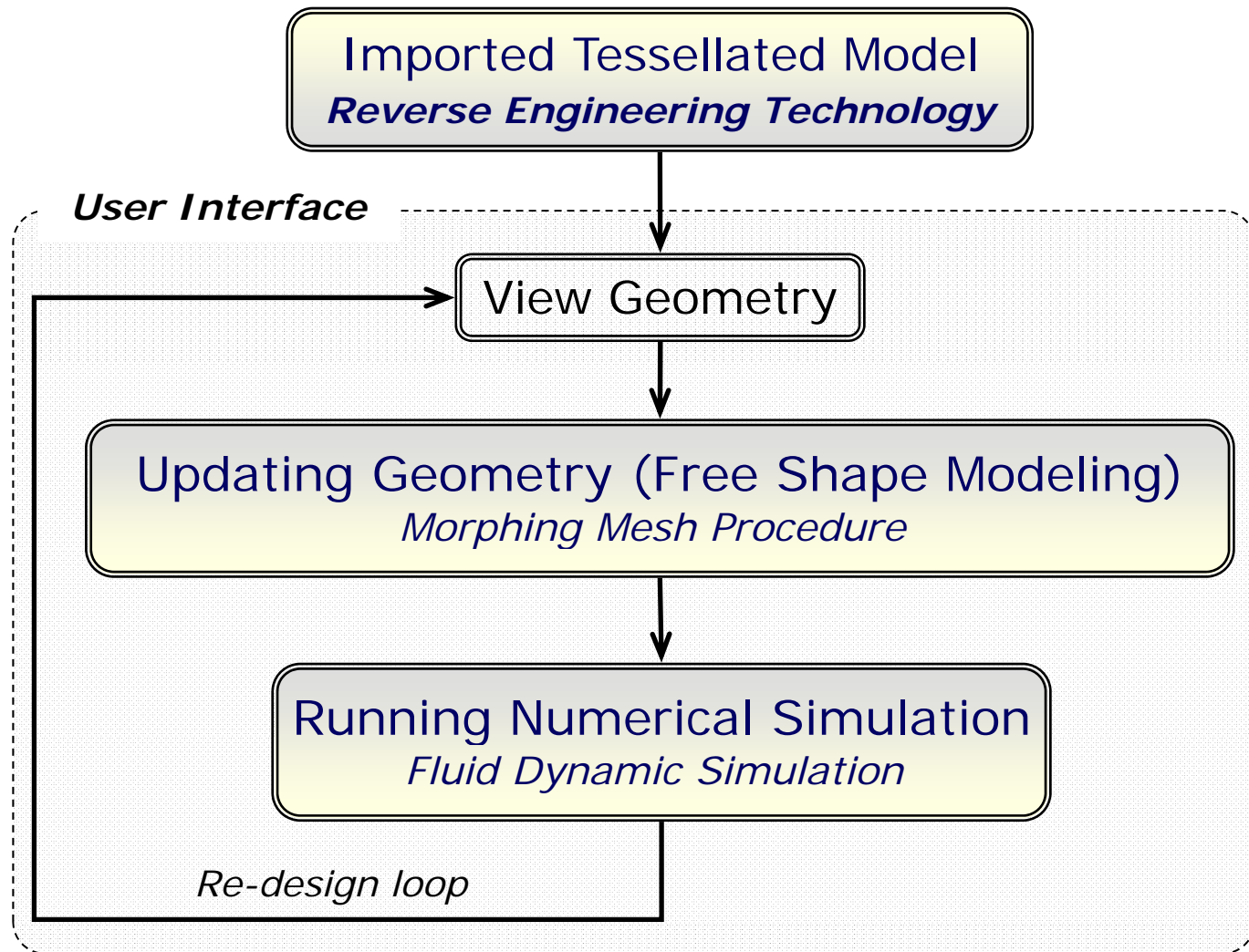
- ❑ During the re-design stage, continuous geometry changing are needed



An interactive tool is then welcome

Introduction and Aims

PRIN Project 2006-2008*



*PUODARSI - *Product User-Oriented Development based on Augmented Reality and Interactive Simulation*

... in this work

□ Re-design loop:

- ✓ ***Free Shape Modeling (mesh-based)***

- ✓ *Running Numerical Simulation*

- ✓ *Viewing Simulation Results-Updating Geometry (interactively)*

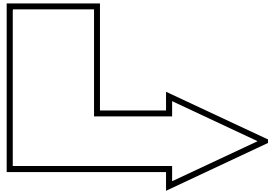
□ Comsol Multiphysics® - Matlab® Integration

Free Shape Modeling

- ❑ **Aim:** update geometry interactively (mesh-based)
- ❑ **How:** by picking few control points from the imported geometry
- ❑ **Solution:** ...

... Morphing Mesh Procedure

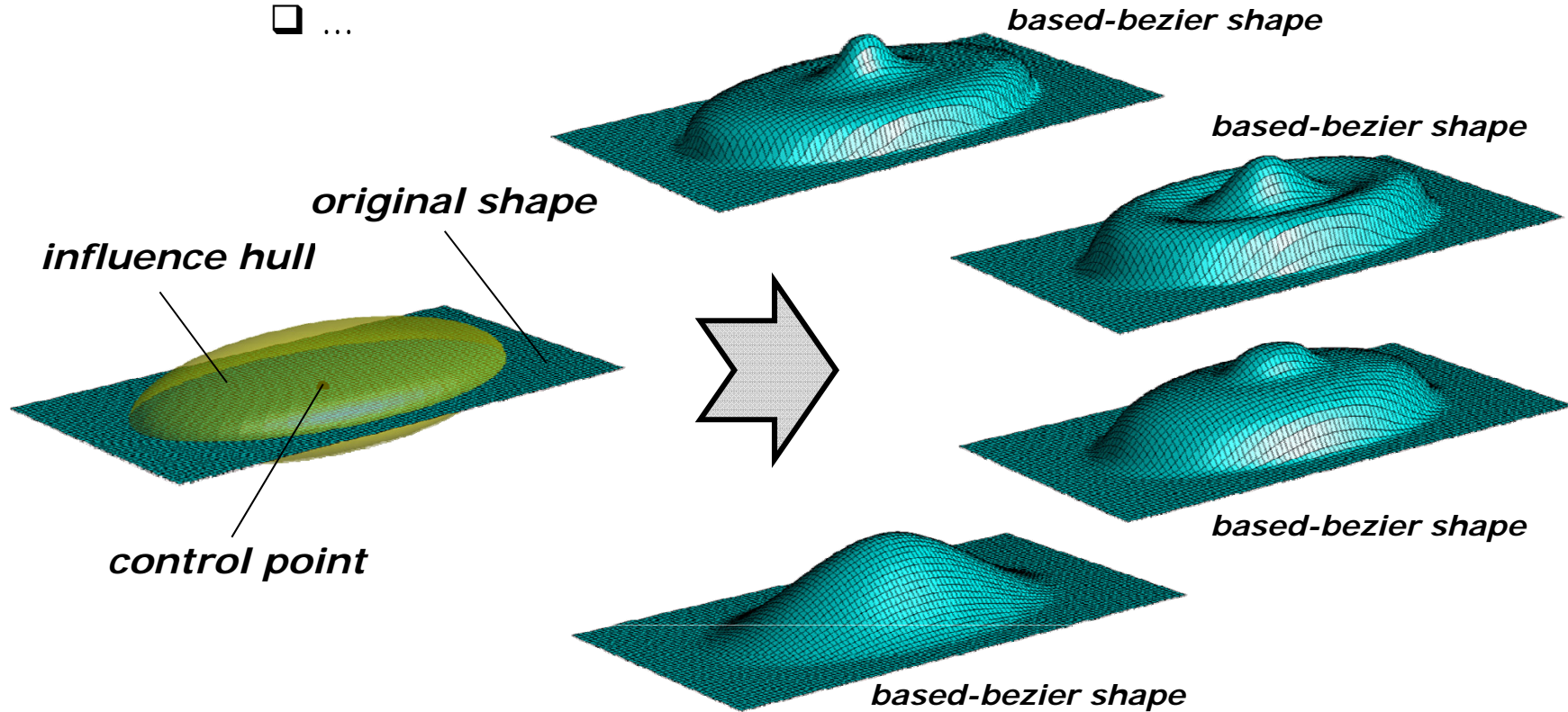
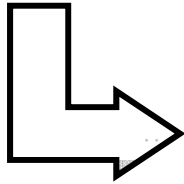
- ❑ Defining control points
 - ✓ User input (picking from graphical interface)
- ❑ Defining influence hulls
 - ✓ User input (ellipsoid domain)
- ❑ Defining weight function
 - ✓ User input (based-bezier shape)
- ❑ Merge Shapes



Morphing Mesh Procedure

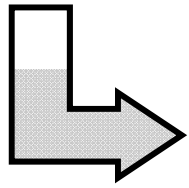
How it works – Weight Function

- ❑ Defining control points
 - ✓ User input (picking from graphical interface)
- ❑ Defining influence hulls
 - ✓ User input (ellipsoid domain)
- ❑ Defining weight function
 - ✓ User input (based-bezier shape)
- ❑ ...



Morphing Mesh Procedure

How it works – Merge Shapes



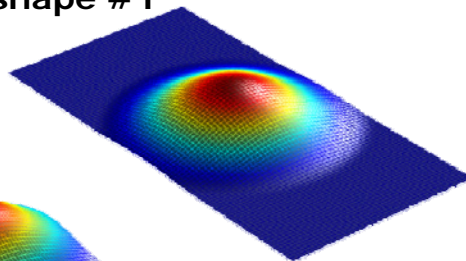
☐ Merge Shapes

✓ Evaluating M matrix

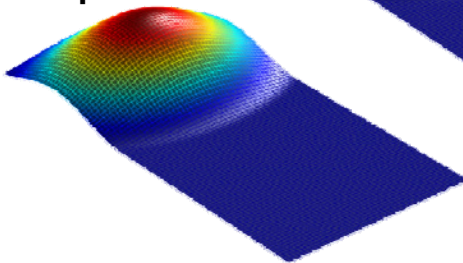


$$\begin{cases} \Delta P_{c1} = W(P_{c1}) \cdot M \\ \Delta P_{c2} = W(P_{c2}) \cdot M \\ \dots \\ \Delta P_{cr} = W(P_{cr}) \cdot M \end{cases} \rightarrow \Delta P_C = W(P_C) \cdot M$$

Control shape #1

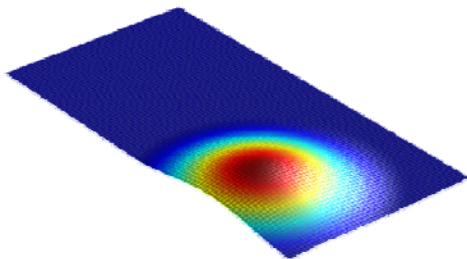


Control shape #2

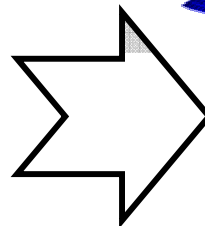


...

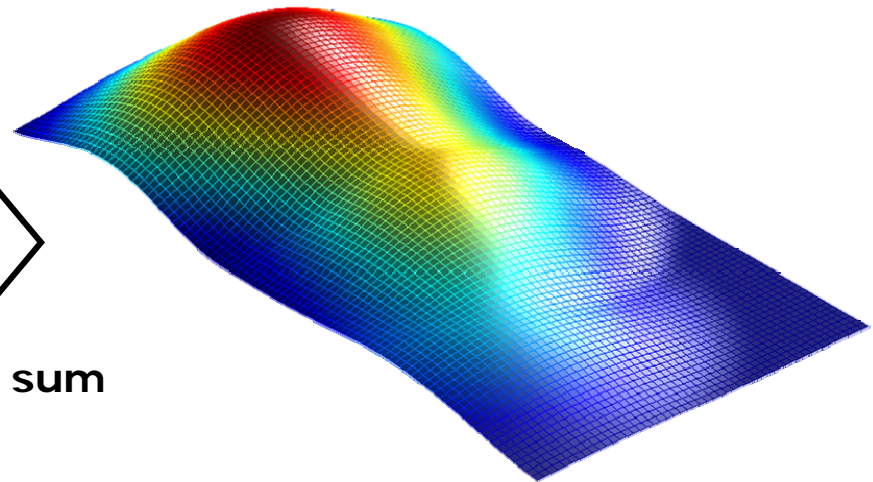
Control shape #r



Morphed Geometry



Weighted sum



... morphed shape depends on influence hull size and weight function

Running Numerical Simulation

Fluid Dynamic Simulation

❑ Fluid Dynamic simulation

- ✓ Laminar Navier-Stokes Comsol® Application mode
- ✓ External flows

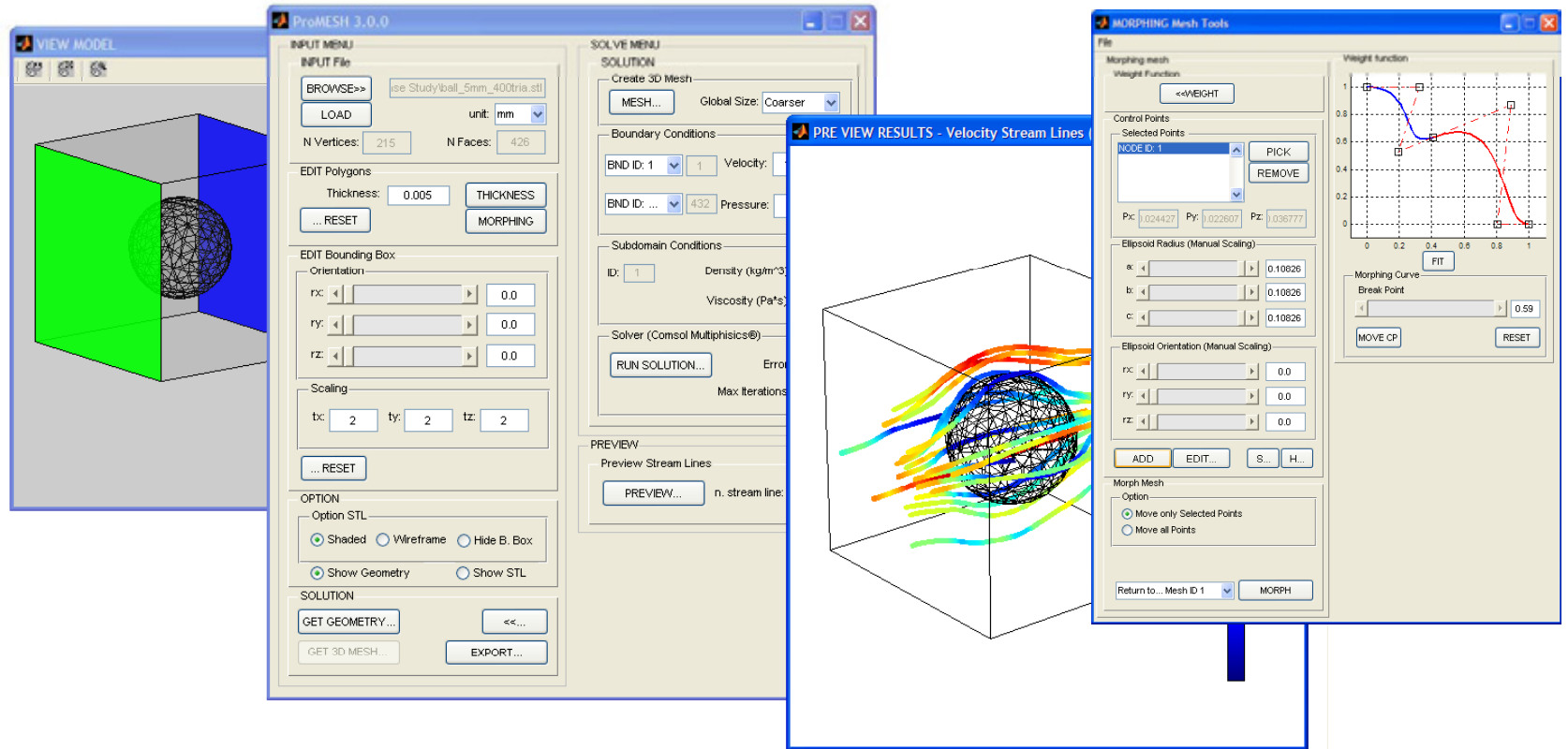
❑ Create geometry

- ✓ Converting mesh geometry to Comsol® geometry object
 - In Comsol® importing procedure may generate some errors, that user cannot easily control
 - Internal Comsol® functions (“face3” and “geomcoerce” used)
- ✓ Creating fluid geometry domain (bounding box)

❑ Run simulation

Matlab® Programming

ProMESH Interface



MatLAB® Programming

ProMESH Interface - Movie

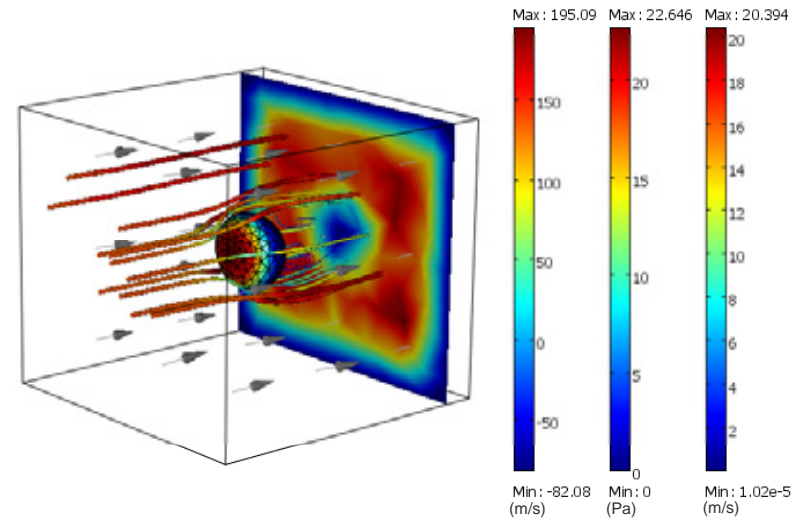
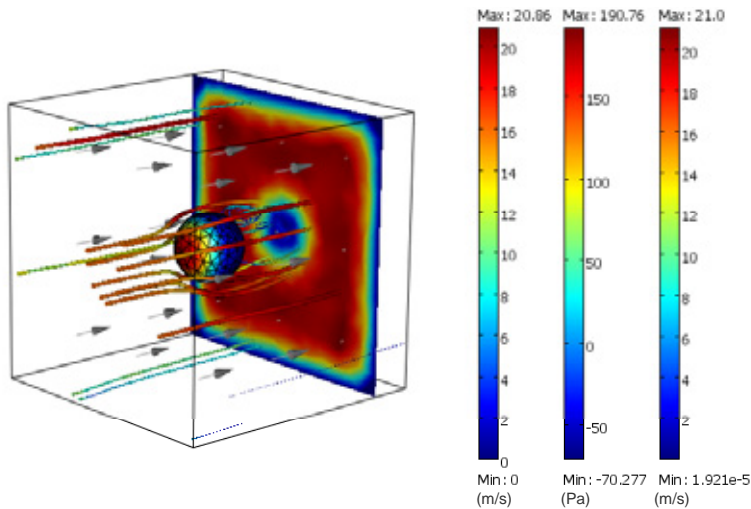
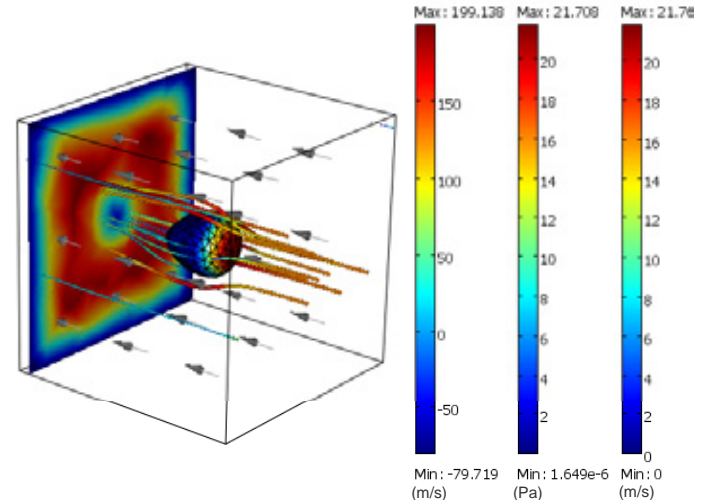
ProMESH 3.0

by P. Franciosa, S. Gerbino

Applications

Imported Closed Domain

Inlet velocity	16.0 m/s
Outlet pressure	0.0 Pa
Shape function	linear
Density	1.19 kg/m ³
Dynamic viscosity	1.85 · 10 ⁻⁵ Pa · s

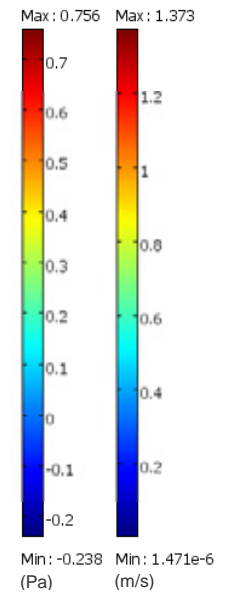
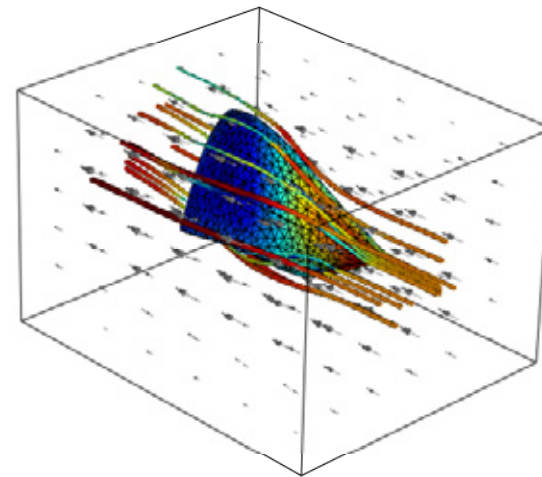
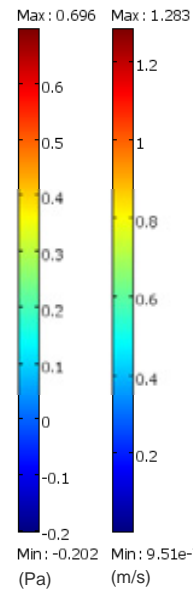
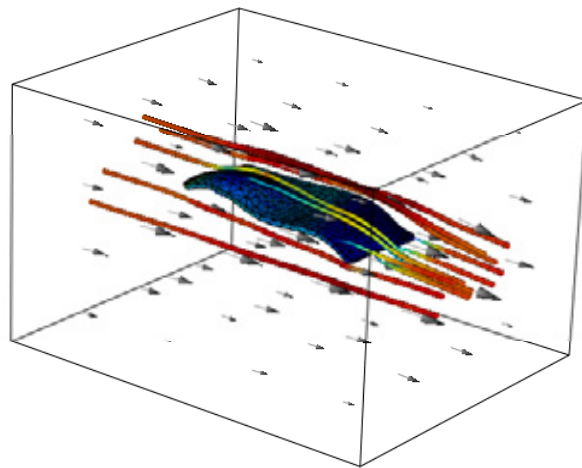
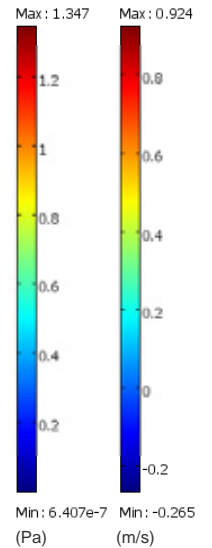
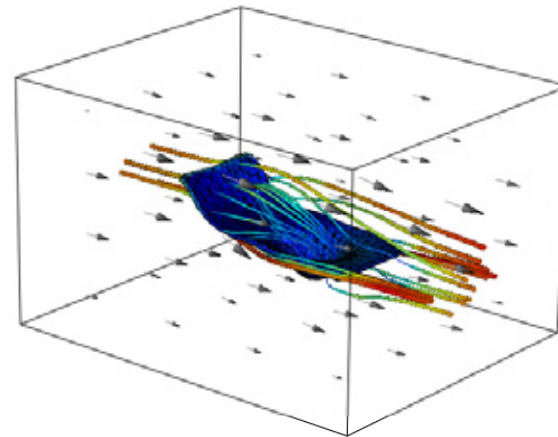


... original geometry: sphere
(D= 100mm)

Applications

Imported Opened Domain

Inlet velocity	1.0 m/s
Outlet pressure	0.0 Pa
Shape function	linear
Density	1.19 kg/m ³
Dynamic viscosity	1.85 · 10 ⁻⁵ Pa · s
Thickness	5.0 mm



**... original geometry: planar surface
(bxh=200x100mm)**

Final Remarks

- ❑ Morphing Mesh for free shape modelling
 - ✓ Control point
 - ✓ Influence hull
 - ✓ Weight function
- ❑ Matlab®-Comsol® integration
- ❑ ProMESH tool to easily manage tessellated models
 - ✓ Importing tessellated models
 - ✓ Morphing geometry
 - ✓ Running simulation
 - ✓ View results & updating geometry

Future Improvements:

- ❑ Decimation algorithm:
 - ✓ to easily manipulate imported tessellated models
- ❑ Re-meshing (mesh optimization) algorithm:
 - ✓ to improve mesh quality of imported tessellated models

Thanks for your attention!

Questions?

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