# VESPA: VTK Enhanced with Surface Processing Algorithms


Charles Gueunet, Tiffany L. Chhim

Kitware Europe



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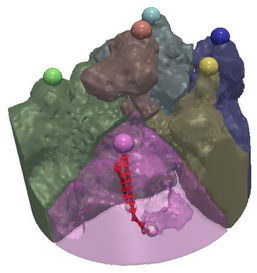
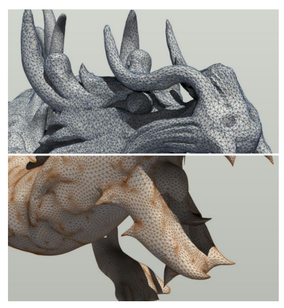
## ParaView

- Leading **open-source** software developed and maintained by Kitware for **scientific visualization**
- Applies to **any scientific domain**: chemistry, computational physics, medical imaging, etc.
- Provides a great variety of post processing filters for **data analysis** and **visualization**
- Can be extended through **plugins**
- Based on the Visualization ToolKit library: **VTK**



ParaView

## CGAL

- The Computational Geometry Algorithms Library
- Robust **open-source** library maintained mainly by GeometryFactory, for reliable **geometric processing**
- Supports a wide range of input meshes thanks to the **Boost Graph Library** [1] and generic programming
- Offers efficient algorithms for:
  - mesh generation, reconstruction and deformation
  - boolean operations
  - mesh classification
- Distributed under dual-licensing: **GPLv3 / Commercial**

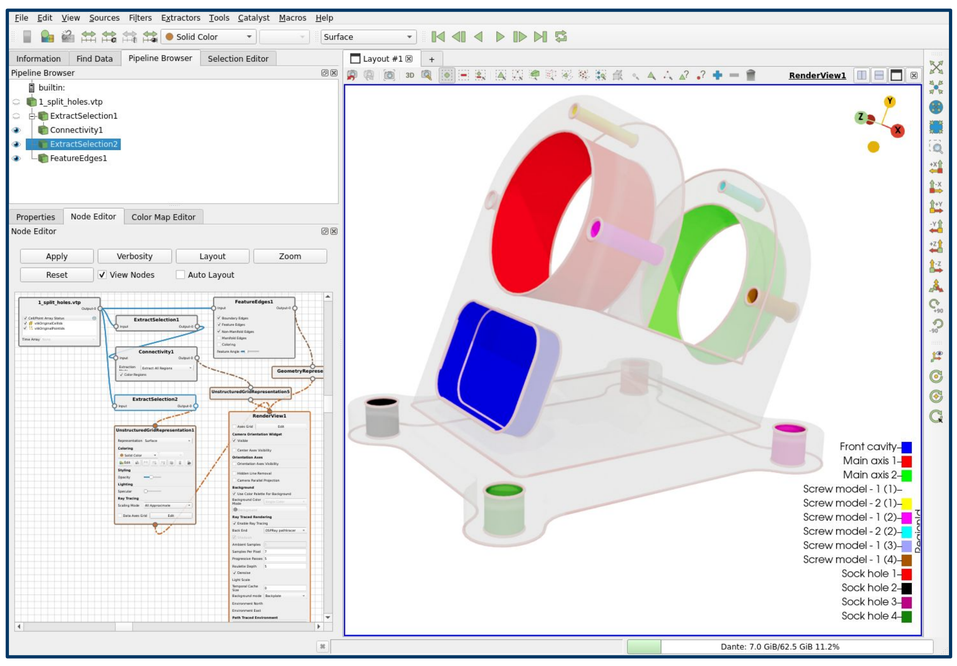
CGAL


[1]: Siek, J. G., Lee, L. Q., & Lumsdaine, A. *The Boost Graph Library: User Guide and Reference Manual, The*. Pearson Education.


## CGAL in ParaView: VESPA

Benefits for **users**:

- As a **ParaView plugin**, VESPA can:
  - ➢ **Interact** with a complete data processing system
  - ➢ Use an advanced **picking** and **selection** mechanism
  - ➢ Display and update results in a controllable 2D / 3D renderer
  - ➢ Access all ParaView filters, readers, writers, exporters, ...




Benefits for **developers**:

- As a **VTK module**, VESPA can:
  - ➢ Take the output of VTK readers and filters (as long as the type is compatible)
  - ➢ Display its output in a VTK rendering **pipeline**
  - ➢ Be **integrated** into applications
- Easy to extend with new CGAL algorithms

## Use Case: Unmolding

**Concept**:
We need to create a shape that englobes our model and can slide along an axis.

**Motivations**:
Medical prosthesis, dental impression, mold casting (die, metal)



1

**Fill** tunnels and cavities.

The removed parts are visible through the surface in color.



2

**Linear extrusion** along the casting axis, and remeshing with **alpha wrapping**.

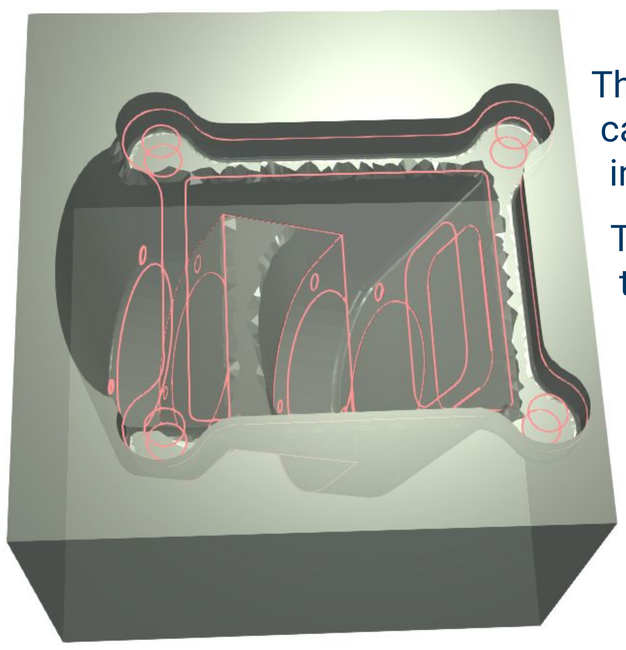
In this example, we consider an unmolding along the red axis.



3

Use a **boolean operation** to “invert” the mesh.

4



This results in a casting die of the initial shape.

The sharp edges of the original mesh are highlighted.

## Pipeline Details

1. The initial shape here is a made up example of a mechanical piece, represented as a 2-manifold triangulation. On each step, the sharp edges of this piece are shown in orange.
2. Using the **vtkCGALPatchFilling** filter, we can **select** areas on the surface that will be remeshed. By selecting tunnels (as shown in color), the filling step then shrinks each boundary while respecting a continuity mode driving the new shape.
3. In order to permit the mold to slide along the vertical axis, we **extrude** each triangle linearly along the z-axis and remesh using the **vtkCGALAlphaWrapping** filter. This also adds a small offset for unmolding and smoothes obtuse edges.
4. Thanks to **vtkCGALBooleanOperation**, we can create a negative of the mesh, corresponding to the final **casting die**. In practice, we may want to try several unmolding axis angles, to reduce the volume of material for example. This can easily be done with the available VESPA filters.


Website: www.kitware.eu

Author contact: charles.gueunet@kitware.com