Scientific Visualization 210: ParaView ~ A Plugin for Geometry Processing

KAUST Visualization Core Lab
www.kaust.edu.sa

October 29, 2023

Scientific Visualization 210: Geometry Processing with ParaView

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Getting Started

- Workshop Materials
  - Visualization Lab Wiki: https://wiki.vis.kaust.edu.sa
  - Training Page: https://wiki.vis.kaust.edu.sa/training/overview
  - Download data slides supplemental material (datasets, Filter xmls): https://wiki.vis.kaust.edu.sa/training/scivis/2023/paraviewvespa | Workshop Materials

ParaView @IT Remote Workstations

- http://myws.kaust.edu.sa/ (Ubuntu 18 only)
- Request access (first time only) at https://kaustforms.formstack.com/forms/remote_workstation_account
- For using VESPA, download binary from workshop page and open a terminal:
  - tar xzvf build.tgz
  - module load qt/5.15.2/gcc-7.5.0-ofwue56
  - module load cuda/11.0.2/gcc-7.5.0-s2uedik
  - ./build/bin/paraview
- Tools->Manage Plugins... Press Load New… and select VESPAPlugin.so from build/bin/plugins

Visualization Core Lab
Overview – Facilities & Services

KVL Training Events

https://wiki.vis.kaust.edu.sa/training/overview
https://www.youtube.com/@kaustvislab

- Scientific Visualization Workshop Series
  - ParaView, VisIt, Avizo/Amira
- Data Science Workshop Series
  - Shell, Conda, Python, Git, and more
- Hands-on AI Tools and Techniques Workshop Series
  - Intro to Machine Learning/Deep Learning, Visualization for Data Science

The Team

Dr. Sohaib Ghani
(LEAD STAFF SCIENTIST)

- VISUAL ANALYTICS
- INFORMATION VIS
- STATISTICAL ANALYSIS

Thomas Theussl
SCIVIS

- SCIENTIFIC VISUALIZATION
- LARGE DATA ANALYSIS
- DISTRIBUTED VISUALIZATION

Dr. James Kress
HPC SCIVIS

- VISUALIZATION SOFTWARE
- HPC INSITU VISUALIZATION
- DISTRIBUTED VISUALIZATION

Dr. Ronell Sicat
VR/AR

- SCIENTIFIC VISUALIZATION
- VR DEVELOPMENT
- 3D RECONSTRUCTION

Dr. Didier Barradas
Data Scientist

- DATA SCIENCE
- MACHINE LEARNING
- DEEP LEARNING

Dr. Abdelghafour Halimi
Data Scientist

- Data Science
- Machine Learning
- Deep Learning

KVL Wiki: Facility Booking, FAQ, and More

https://wiki.vis.kaust.edu.sa

Visualization Laboratory Wiki

Search docs

- Welcome to the KVL
- Welcome to the KAUST Visualization Core Lab (KVL)
  - Who We Are
  - Core Services
  - Mission
  - Contact Us
  - Location
  - Recent Highlights
  - Video Overview
  - People
- Training Events
- Facilities
- Highlights

KVL Documentation

- Frequently Asked Questions
- Visualization Tools User Guides
- VR Tools User Guides
- Data Science Tools User Guides
- Facility User Guides

Docs » start

Welcome to the KAUST Visualization Core Lab (KVL)

Who We Are

The KAUST Visualization Core Laboratory is a state-of-the-art facility within the Core Labs that offers students, faculty, researchers, and university collaborators a unique opportunity to utilize one-of-a-kind visualization, interaction, and computational resources for the exploration and analysis of scientific data.

Core Services

Our mission is to support the data visualization and data science needs of KAUST researchers and In-Kingdom entities. To that end we have a varied range of expertise across the team. Contact us with your questions, project requests, or collaboration requests that fall within our service areas:

- **2D/3D Visualization Facilities**
  - We provide a unique set of visualization and meeting facilities on campus.
  - Contact us for inquiries or use your KAUST credentials to create a booking.
- **Data Visualization and Data Science Workflows**
  - We support KAUST users with visualization workflows, VR workflows, and data science/machine learning.
  - Contact us for additional information, to submit a general request, or request a collaboration.
- **Training and Workshops**
  - We have a wide variety of trainings available on our YouTube Channel as well as select trainings performed in-person each semester.

Mission

To support the needs of KAUST researchers and In-Kingdom entities by:

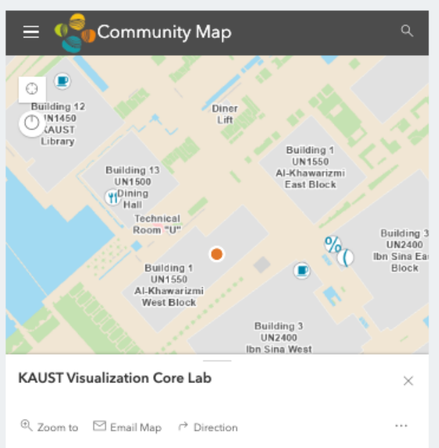
- Developing and maintaining an effective and efficient environment for data exploration and analysis
- Providing advanced visualization and data analysis services
- Providing training on state-of-the-art visualization hardware and software for scientific discovery
- Developing new capabilities to remain at the cutting edge of visualization and data science

Contact Us

help@vis.kaust.edu.sa
KVL YouTube Channel
KVL Twitter
Core Labs Website
KVL Core Labs Main Website

Location

Our main showcase facility is located @:
Building 1 (seaside), Level 2, Showcase



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Workshop: Goals and Agenda

Workshop Goals

Demonstration of latest geometry processing tools in ParaView

- Motivation for geometry processing in ParaView
- Existing options in ParaView
- Enabling VTK filters not available in ParaView (yet)
- VESPA – a geometry processing plugin for ParaView using CGAL

Today’s Agenda

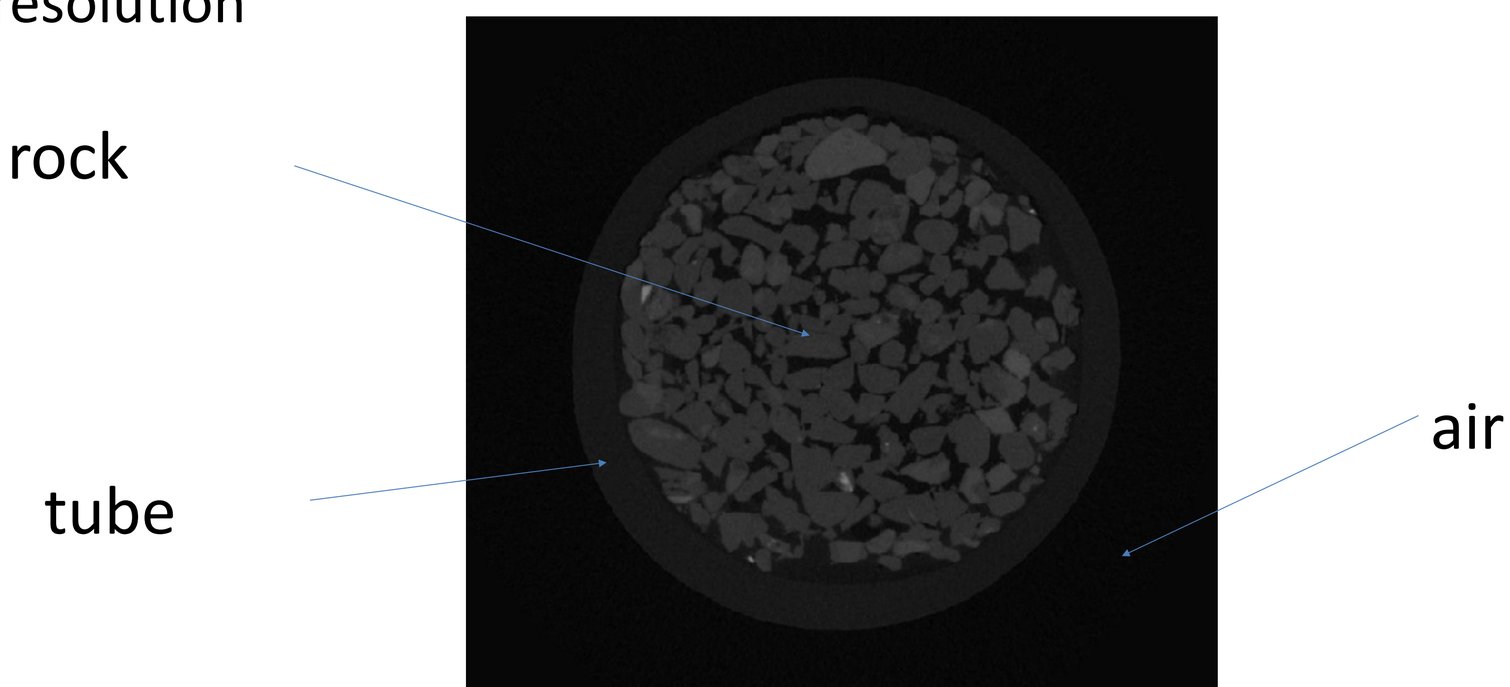
Time	Topic	Speaker
~10 min	Introduction and motivation for geometry processing in ParaView	Thomas Theußl
~25 min	Visualization case studies	Thomas Theußl
~25 min	Enabling VTK Filters - Contouring of Label Maps	Thomas Theußl
~10 min	— break —	-
~25 min	Overview of CGAL and using the VESPA plugin	Thomas Theußl
~25 min	Compiling and extending the VESPA plugin	Thomas Theußl
on demand	Q&A / Discussion	all

Visualization Case Studies

Dataset

provided by
Jamal AlAamri, Ali I. Al-Naimi Petroleum Engineering Research Center (ANPERC)

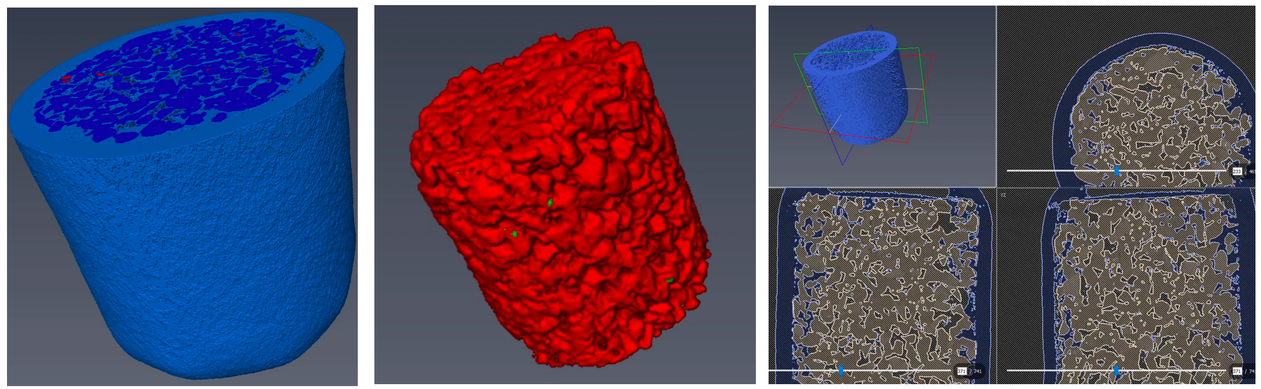
- mini core plug isolated inside a shrink tube
- the rock represents a sandstone, a type of rock found in oil and gas reservoirs
- 466 png images of 742x742 resolution



Volume Segmentation

Basic volume segmentation techniques:

- Thresholding
- Watershed algorithm
- Segmentation editor



Advanced training course:

Scientific Visualization 210: Avizo and Ilastik for Image Segmentation and 3D Analysis

Date

- Sunday November 5, 2023
- 1:30pm - 4:00pm

Venue

- Auditorium between Bldgs. 3 and 5

Organizer

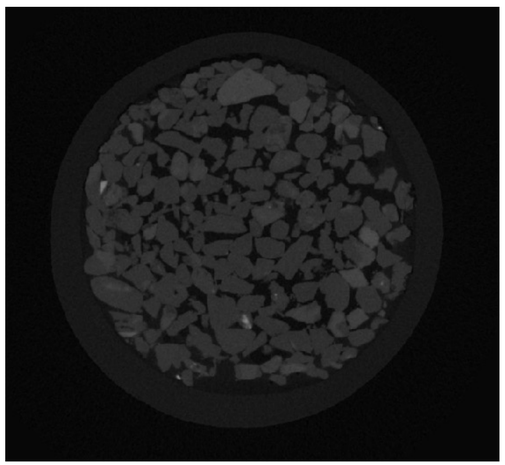
Ronell Sicat
Visualization Core Laboratory
ronell.sicat@kaust.edu.sa

Register

Register here!

https://wiki.vis.kaust.edu.sa/training/scivis/2023/avizoilastik

Watershed Algorithm



Original Volume

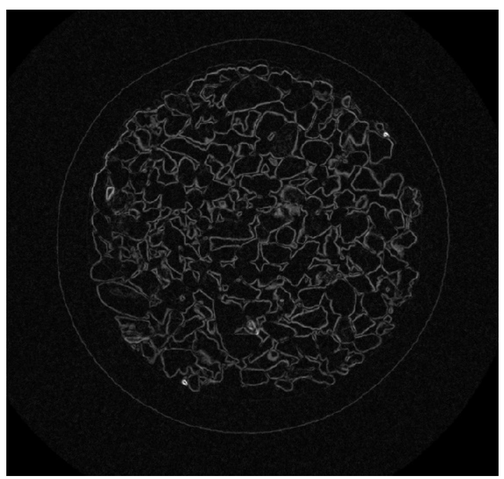
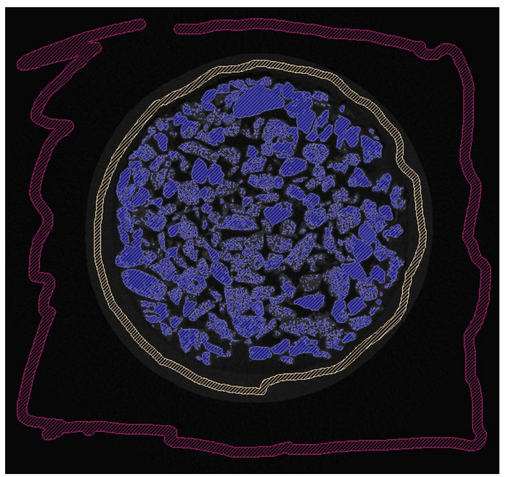


Image Gradient

+

Markers



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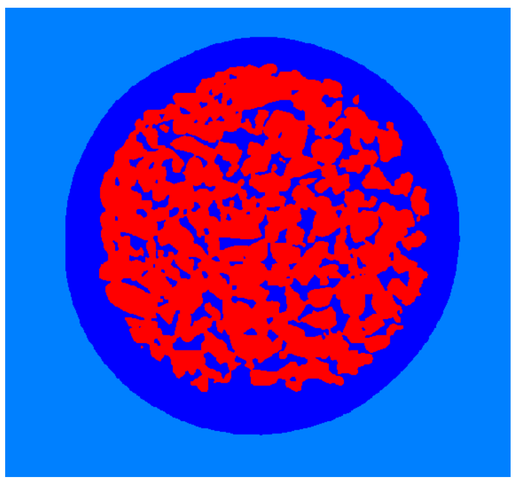
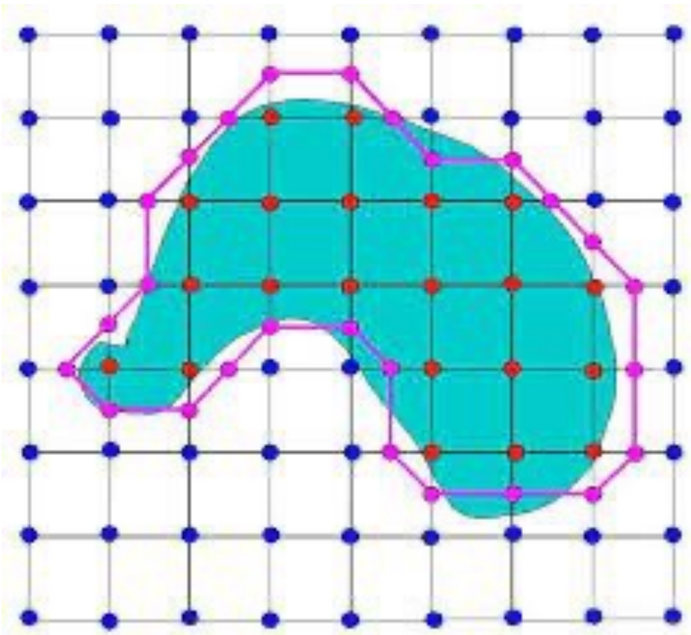
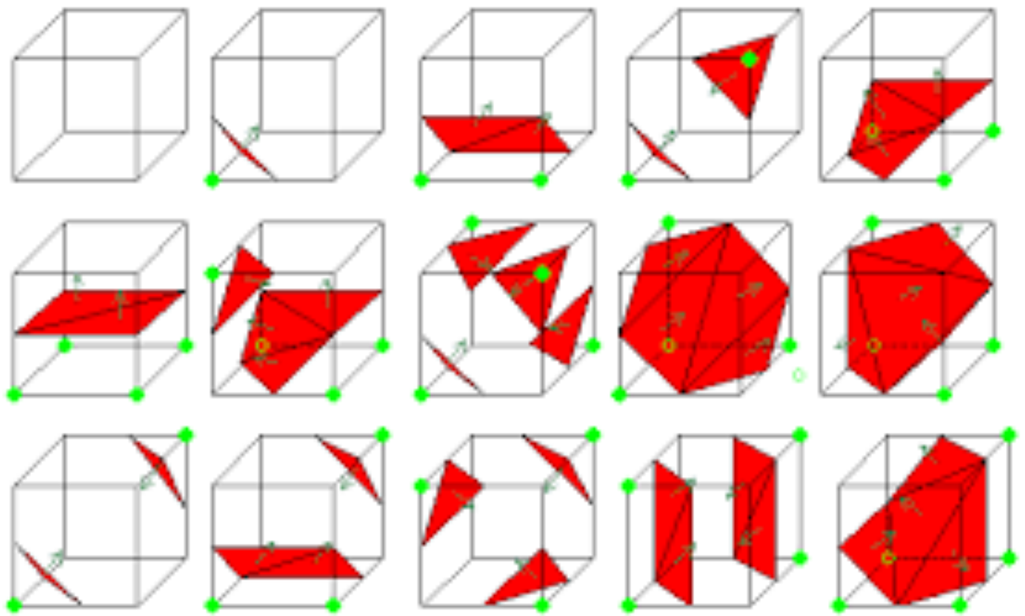
Segmentation



Marching Cubes





Problems:

- Too many triangles
- Non-isotropic triangles
- Staircase artifacts (especially when used on segmentation masks)

Geometry Processing with ParaView

ParaView has only limited support for geometry processing, some useful filters are:

- Contour
- Connectivity
- Threshold
- Extract Surface
- Smooth
- Decimate

- Demo-

Enabling VTK Filters - Contouring of Label Maps

Enabling VTK Filters

- Tools->Manage Plugins…
- Press ‘Load New…’ and select xml file
- To create xml, copy Template.xml and edit accordingly:
  - https://www.paraview.org/Wiki/ParaView/Plugin_HowTo#XML_Only
  - https://www.paraview.org/Wiki/ParaView/Plugin_HowTo#Adding_GUI_Parameters

Contouring of Label Maps

- Discrete Marching Cubes 3D
  - Roman Grothausmann, "Providing values of adjacent voxel with vtkDiscreteMarchingCubes", the VTK Journal.
  - http://www.vtkjournal.org/browse/publication/975
- Discrete Flying Edges 3D
  - Schroeder, Maynard, Geveci, "Flying Edges: A High-Performance Scalable Isocontouring Algorithm", Proc. of LDAV 2015. Chicago, IL.
- Surface Nets 3D
  - S. Frisken (Gibson), "Constrained Elastic SurfaceNets: Generating Smooth Surfaces from Binary Segmented Data", Proc. MICCAI, 1998, pp. 888-898.
  - S. Frisken, "SurfaceNets for Multi-Label Segmentations with Preservation of Sharp Boundaries", J. Computer Graphics Techniques, 2022.

- Demo-

Overview of CGAL and using the plugin

CGAL Mission Statement

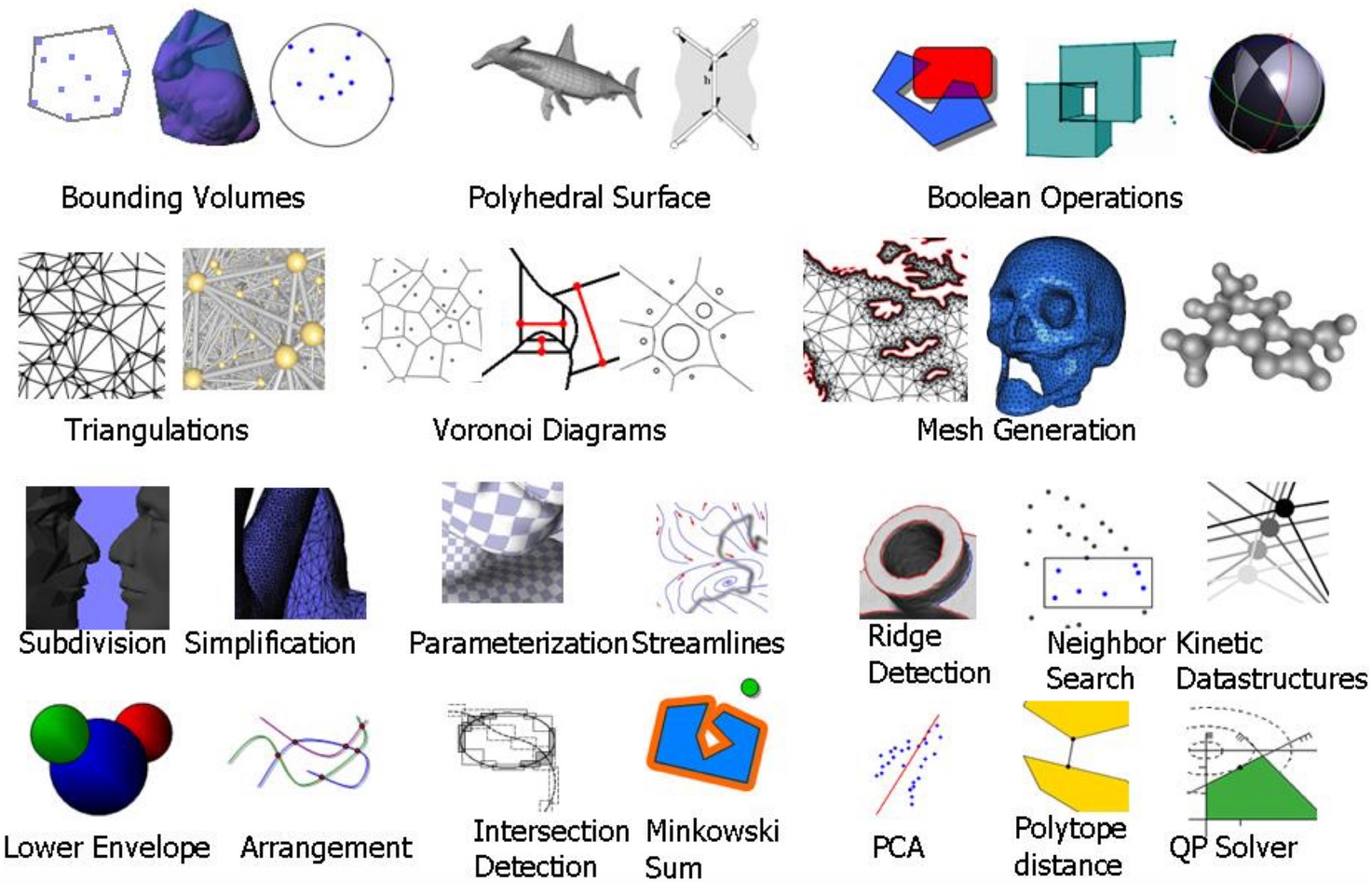
"Make the large body of geometric algorithms developed in the field of computational geometry available for industrial applications"

CGAL Project Proposal, 1996

CGAL Overview

https://www.cgal.org

Algorithms and Datastructures



CGAL in Numbers

- 500,000 lines of C++ code
  10,000 downloads/year (+ Linux distributions)
- 3,500 manual pages
  3,000 subscribers to cgal-announce 1,000 subscribers to cgal-discuss
- 120 packages
  90 commercial users
  20 active developers
  12 months release cycle
- 2 licenses: Open Source and commercial

Compiling CGAL examples

- https://doc.cgal.org/latest/Manual/packages.html
- Use `Scripts/scripts/cgal_create_CMakeLists` to create CmakeLists.txt
- `mkdir build && cd build`
- `cmake -DCGAL_DIR=<cgal_directory>/build -DCMAKE_BUILD_TYPE=Release ..`

- Demo-

Available CGAL algorithms in ParaView

- Alpha Wrapping
- Boolean Operation
- Delaunay 2D
- Hole Filling
- Isotropic Remesher
- Mesh Checker
- Mesh Deformation
- Mesh Smoothing
- Mesh Subdivision
- Region Fairing
- Shape Smoothing

- Demo-

Compiling and Extending the Plugin

- Demo-

Summary

- ParaView itself has only limited possibilities for geometry processing
- VTK filters can be enabled by providing xml files
- VESPA plugin provides access to some algorithms from CGAL
  - has to be compiled from source
  - binaries available for use on IT remote workstations (Ubuntu 18)
- SurfaceNets3D requires compiling latest ParaView version (no official release yet)