An update on VTK, ParaView and trame

Sebastien Jourdain, Kitware Inc.

Advanced Modeling & Simulation (AMS) Seminar Series

NASA Ames Research Center, July 2nd, 2024

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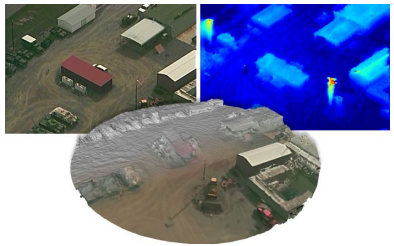
Outline

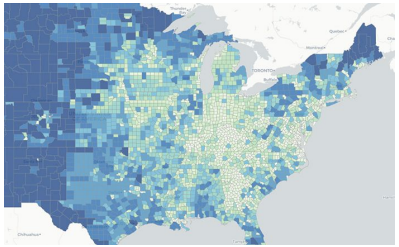
- **Introduction to Kitware Inc.**
  - What we do?
  - Who we work with?
- **VTK/ParaView advancement**
  - Performance, Rendering, In-situ
  - What's next?
- **Trame**
  - What is it?
  - What can you do with it?

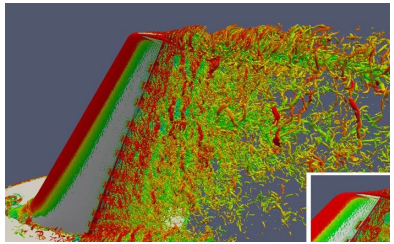
Kitware

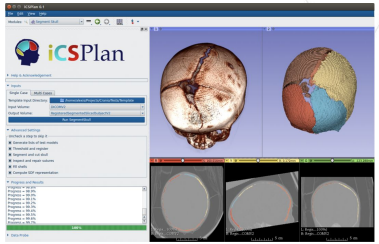
What we do?

Areas of expertise / Built on open source









Computer Vision

Data and Analytics

Scientific Computing

Medical Computing

Software Solutions

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Making the world a better place through custom software solutions

Customers / Various fields of application

Academics

70+ academic institutions worldwide

Government agencies

50+ government agencies and national laboratories

Commercial companies

Over 500 commercial customers



Medical

Image processing, multimodal visualization, image registration & segmentation, assisted surgery, custom software…

Energy

HPC, in-situ simulation, scientific visualisation, particle flow, fluid mechanics, ground exploration…

Intelligence

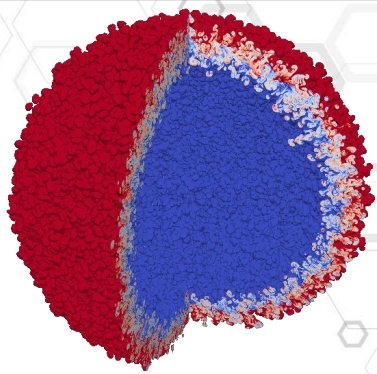
Scene analysis, big data analysis, scientific visualization, flow analysis…

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VTK / ParaView

Performance, Rendering, In-Situ

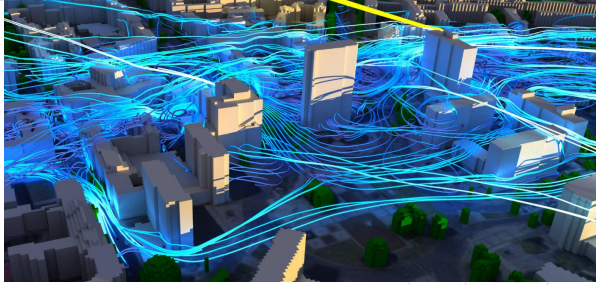
Performance improvements



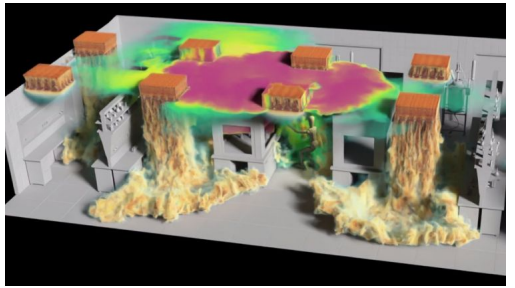
- **New data parallel algorithms**
  - Replace aging algorithm to better leverage today's hardware
  - Threaded (STDThread, TBB, OpenMP) and/or vtk-m (https://m.vtk.org/)
  - Research paper (EGPGV 2024)
- **Affected filters since 2022**
  - vtkMergeVectorComponents, vtkExtractVectorComponents, vtkArrayCalculator, vtkExtractHistogram, vtkVortexCore, vtkMeshQuality, vtkPointDataToCellData, vtkStreamTracer, vtkParticleTracer, vtkGeometryFilter, vtkResampleWithDataSet, vtkCutter, vtkTableBasedClipDataSet…
- **ParaView is enabling vtk-m filters when possible (5.12)**
  - Clip, Slice, Threshold

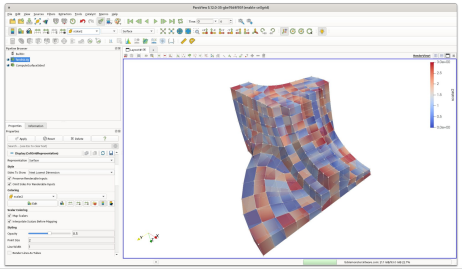
https://www.kitware.com/vtk-paraview-filters-performance-improvements/

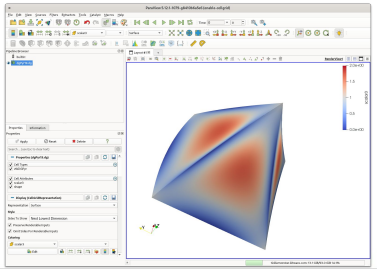
Rendering

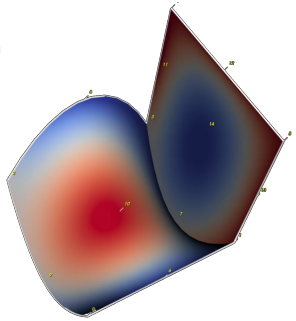


- **VTK/ParaView support many rendering Backend**
  - OpenGL, OSPRay, IndeX, **ANARI**, Omniverse
  - OpenVR, OpenXR, Looking Glass
- **Working on OpenGL replacement**
  - **WebGPU** for both desktop and web
- **Discontinuous Galerkin Rendering support**
  - PV 5.13









In-Situ (Catalyst v2.0)

ParaView Catalyst provides a small, easy-to-use, API that any simulation developed in C++, C, Fortran or Python can use to do in situ analysis without developing its own custom data analysis code.

- New documentation section in ParaView 5.12
  - https://docs.paraview.org/en/latest/Catalyst/
- New conduit protocol for `amrmesh`
- ParaView 5.13
  - Steering extractor + direct access to conduit
- NASA SBIR - end early 2025
  - Accelerating Design of ML and AI Experiments in Scientific Simulation

ParaView 5.12 - Miscellaneous

- **Data processing**
  - Add boundary mesh quality filter
  - PNG can be used to save/load ParaView state
- **Readers**
  - *New* - NetCDF UGRID, **STEP**, **IGES**, FDS
  - *Updated* - IOSS (exodus)
- **GUI improvement**
  - Multiblock inspector, Color-Opacity editor, Copy/Paste pipeline, Node editor…
  - Unified “Time Manager” panel

What's next for VTK?

- **WebGPU (2025)**
  - Next cross platform open standard
  - Targeting 2025 for most of geometry rendering
- **Python wrapping: auto-generated pythonic API (9.4)**
  - Constructor initialization
  - Dot notation for properties
  - Native integration with numpy/Xarray
- **WASM (9.4)**
  - VTK rendering can be done better in your browser

What's next for ParaView?

- **VTK improvement will benefit ParaView**
  - Speed, WebGPU, WASM
- **ParaView Next**
  - Asynchronous framework as a non-blocking solution
  - Independant services (data-service, rendering-service)
  - Web Based User Interface (using trame)
  - Infrastructure available for data processing and rendering
    - Missing some capabilities - need support



Trame

Getting more with less



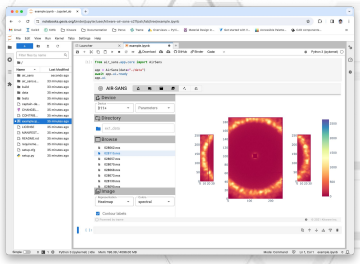


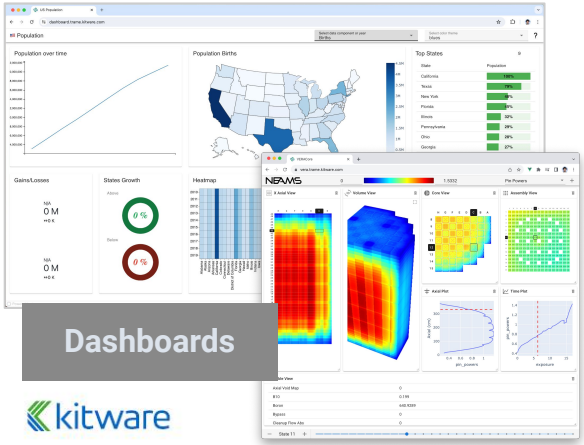
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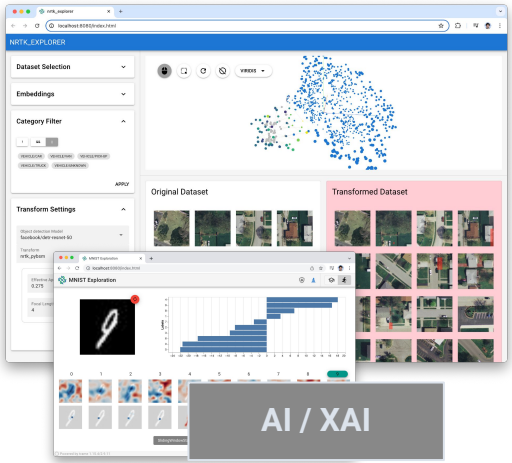
https://kitware.github.io/trame/

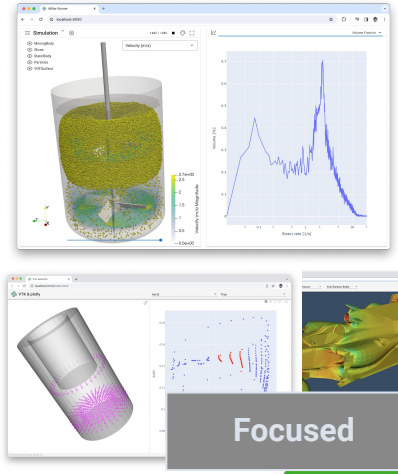
What is trame?

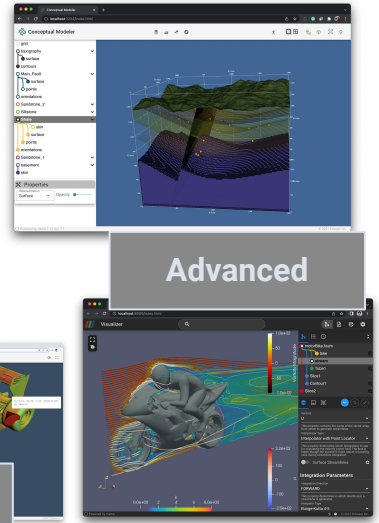
- Python library for creating interactive applications with a web front-end without the Web complexity!
- Trame applications can then be used on desktop, client/server, cloud, Jupyter and HPC.





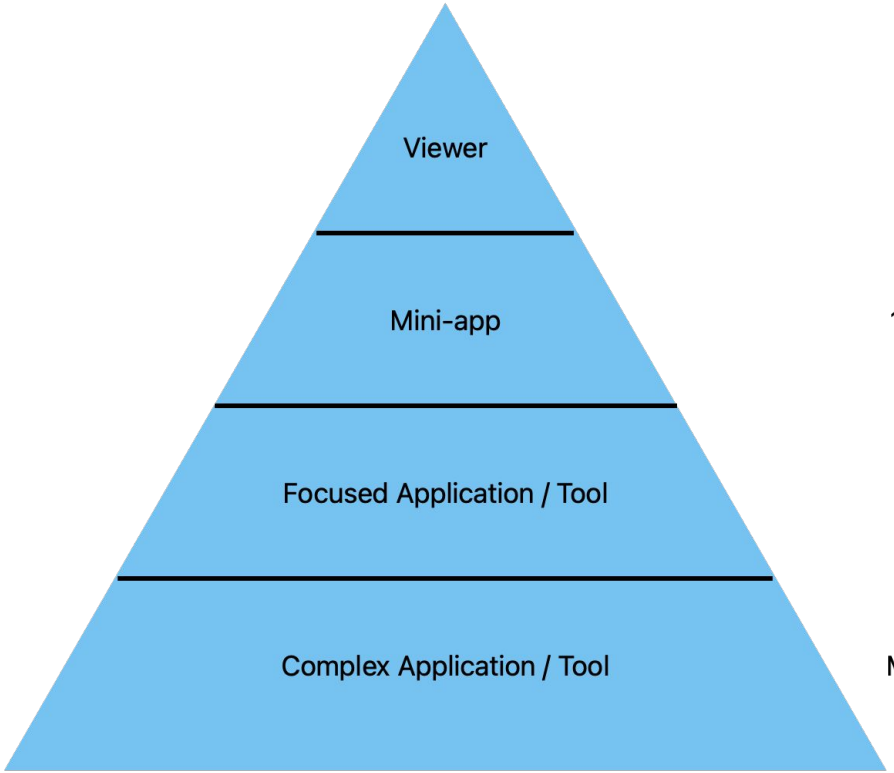






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Usage examples (1/5)



1 Python file ~ 10 lines

1 Python file ~ 500 lines

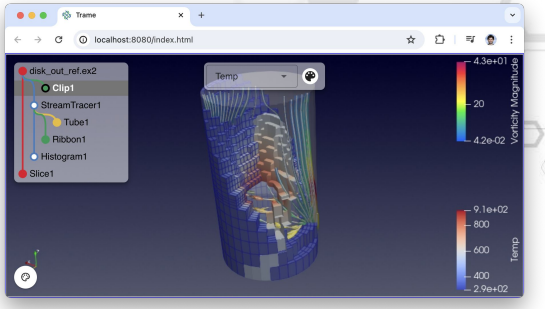
3-6 files ~ 1500 lines

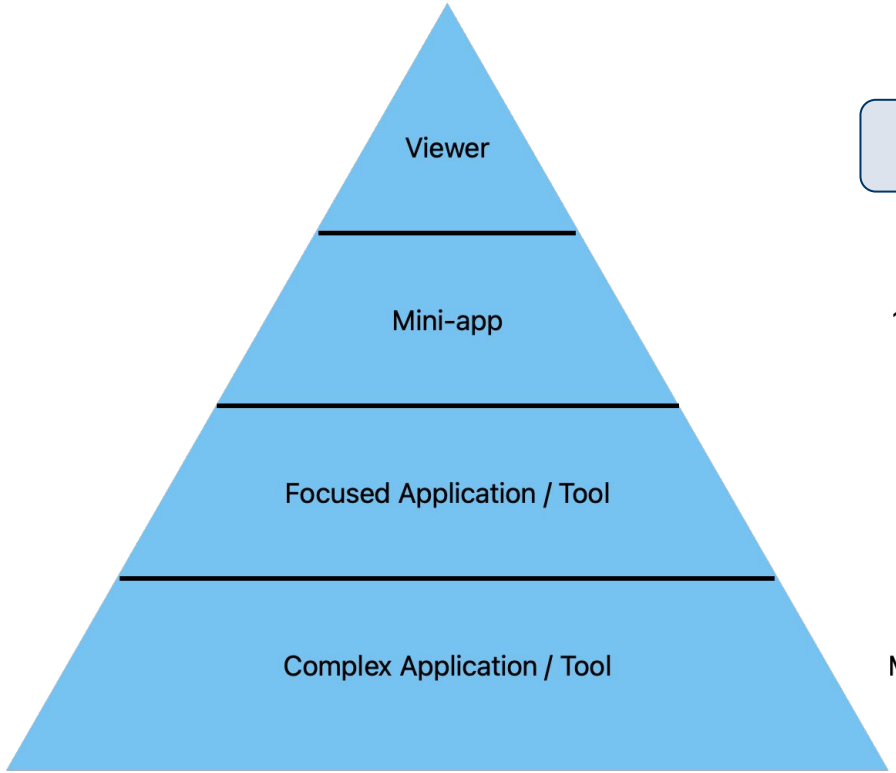
Many files ~ +2000 lines



Usage examples (2/5)





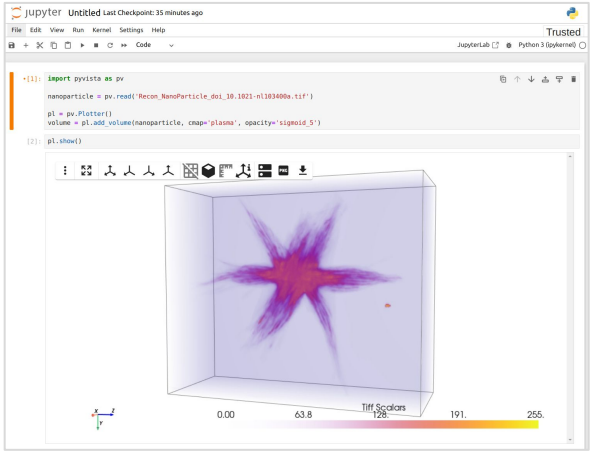


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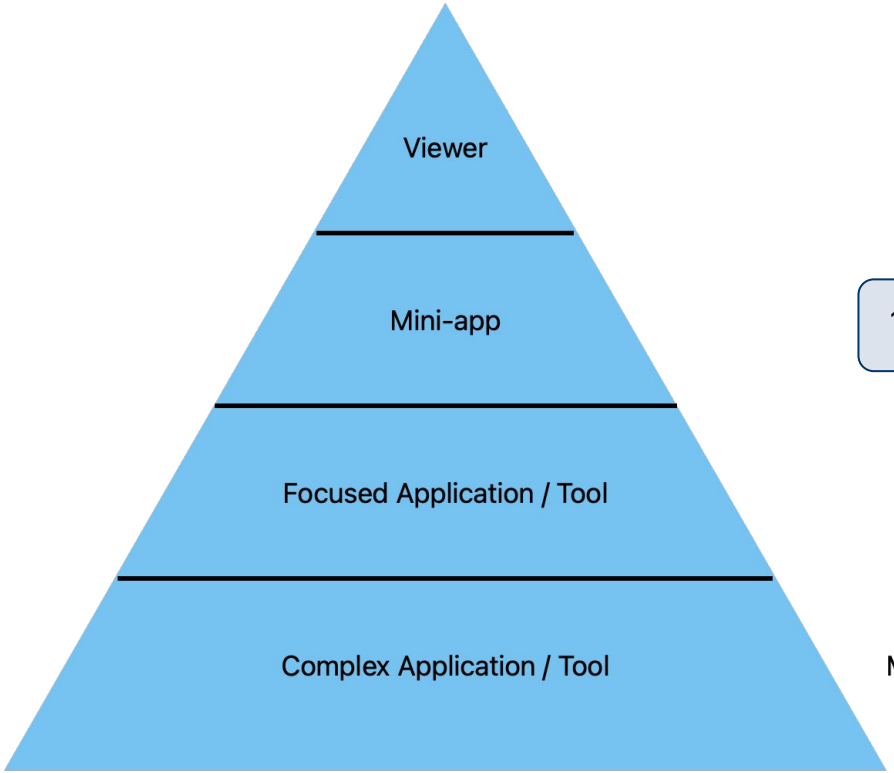
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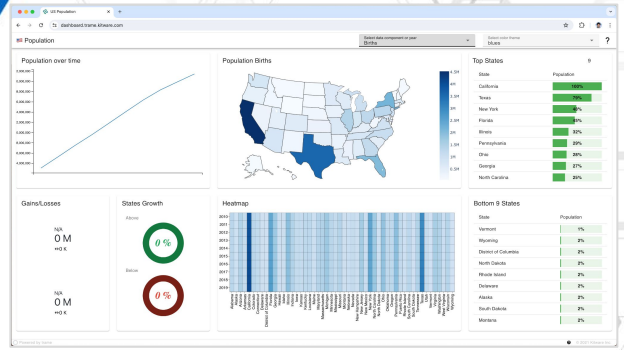


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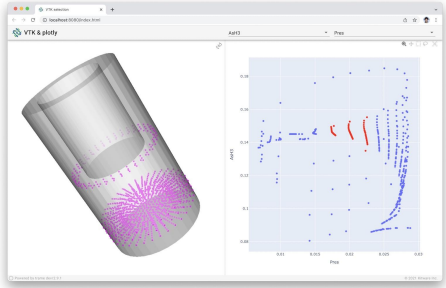
Usage examples (3/5)



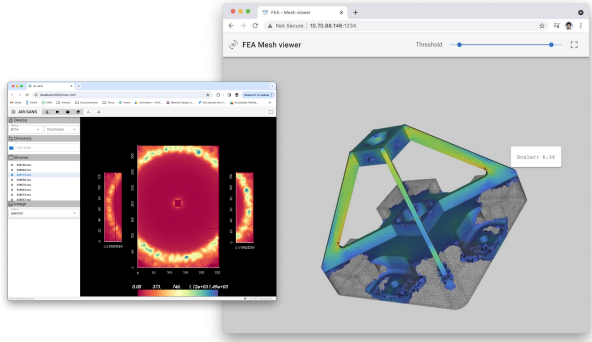
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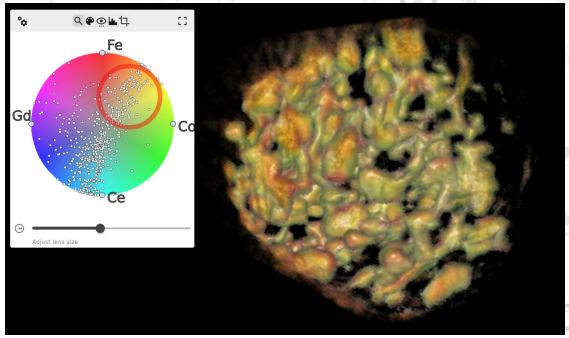
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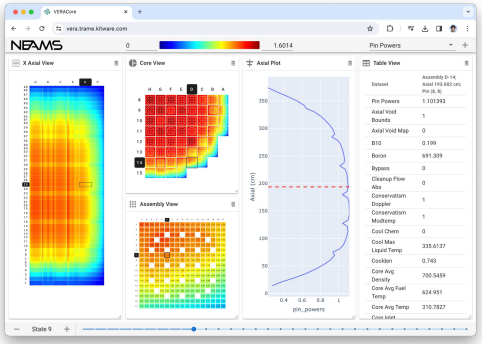


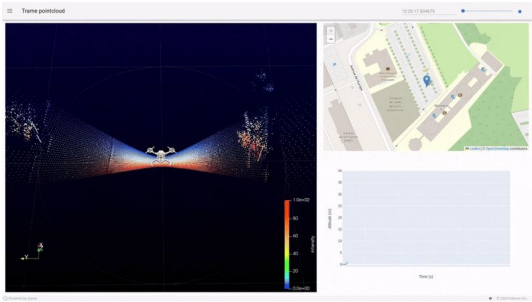
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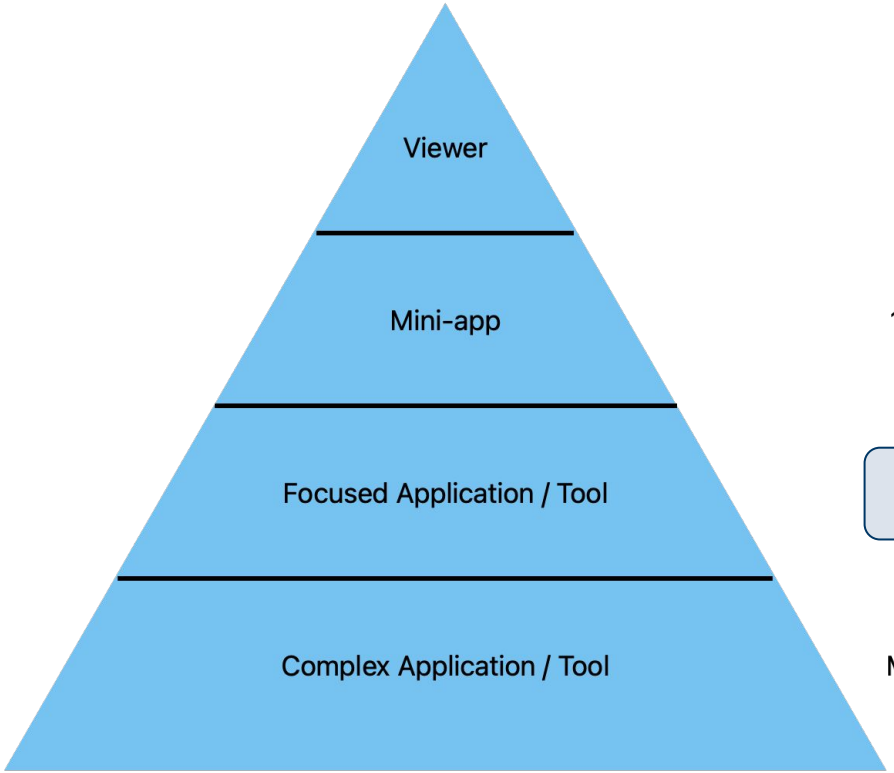
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Usage examples (4/5)









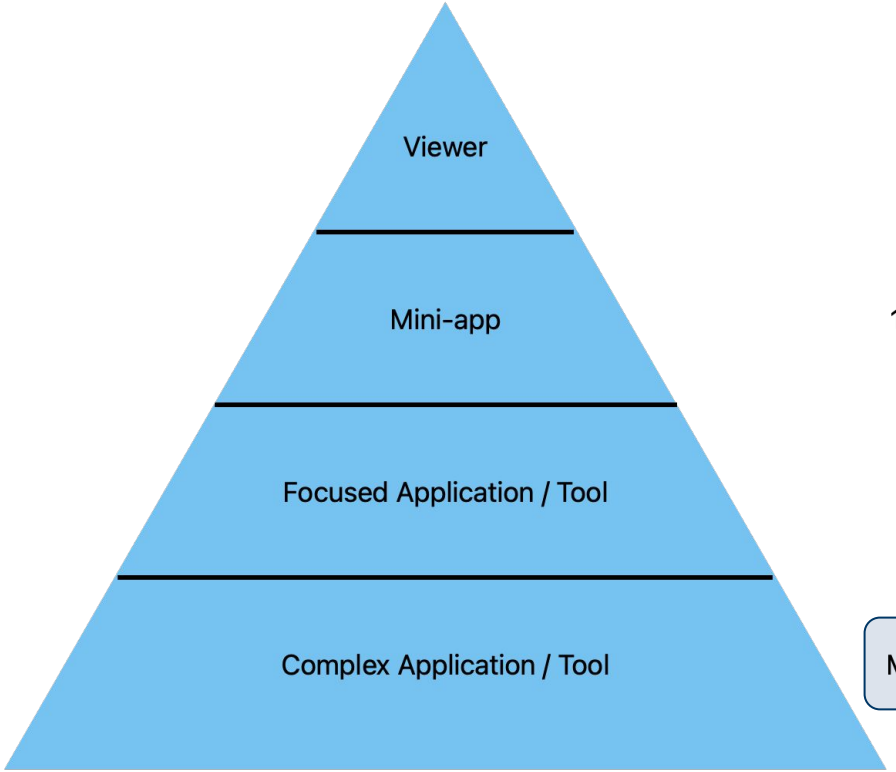
1 Python file ~ 10 lines

1 Python file ~ 500 lines

3-6 files ~ 1500 lines

Many files ~ +2000 lines

Usage examples (5/5)

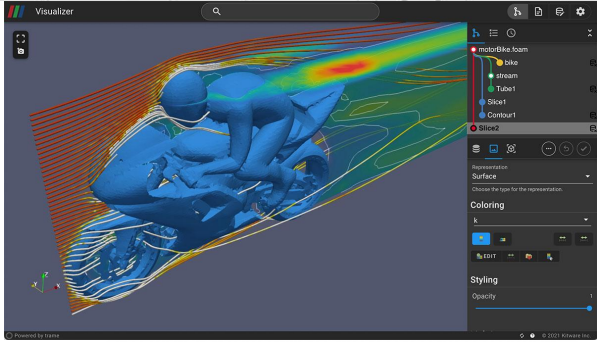


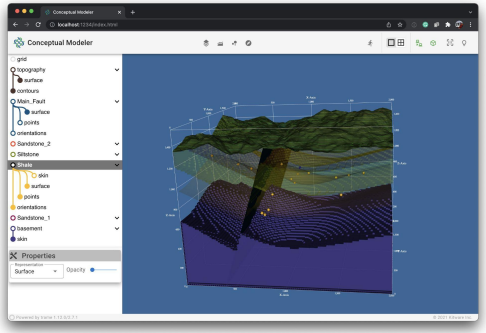
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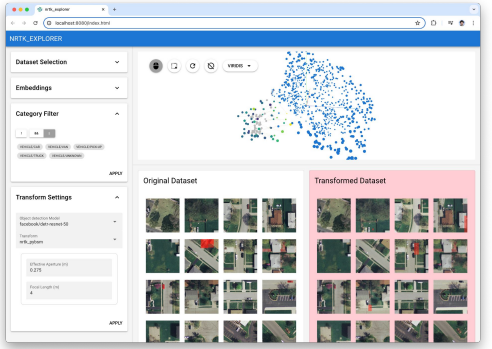
1 Python file ~ 500 lines

3-6 files ~ 1500 lines

Many files ~ +2000 lines







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Nothing is too big or too small for trame

- From visualization to interactive data processing
- Running locally or on HPC
- Within Jupyter or in the cloud
- Trame has you covered

What you do with it is up to you…



It is like playing lego…





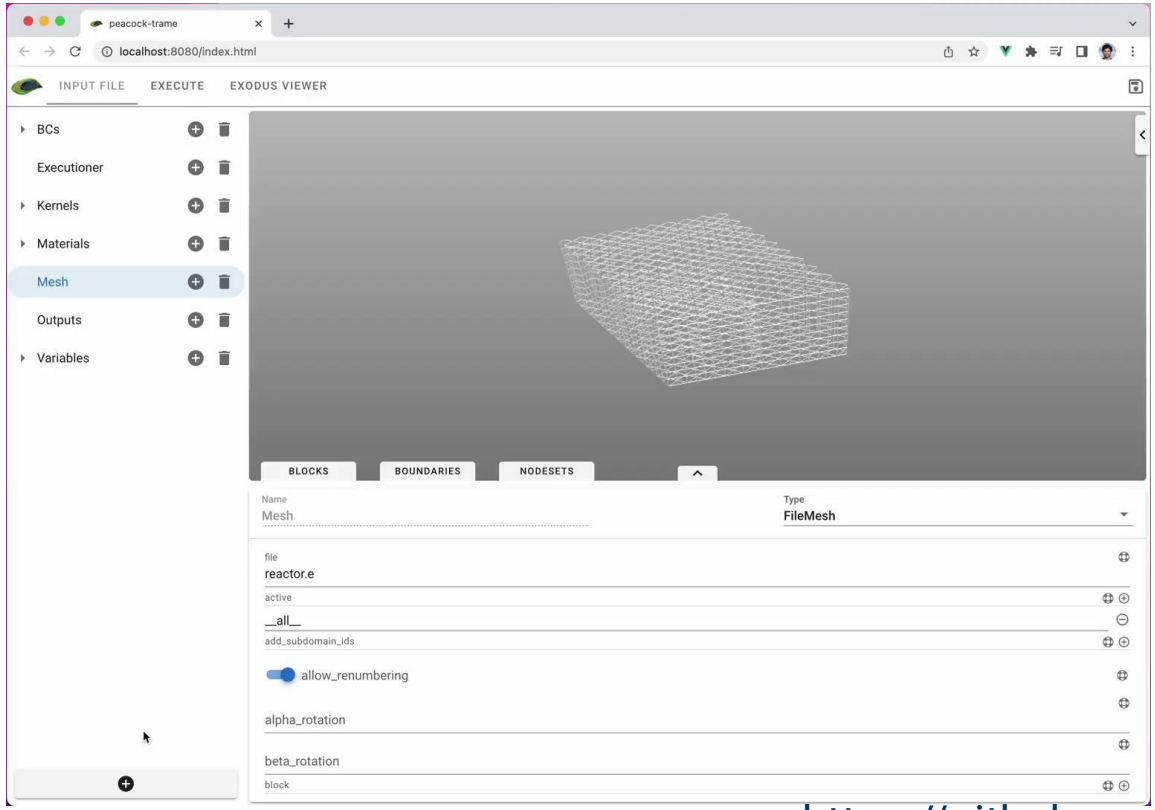


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What can you do with it?

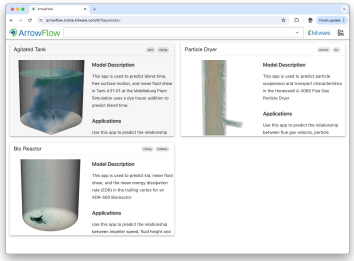
- **Use case 1 - Simulation and post-processing**
  - Complex simulation input with Peacock
  - Template based simulation with ArrowFlow
- **Use case 2 - Data exploration**
  - Nuclear reactor core simulation result with VeraCore
  - XAITK a toolkit for understanding your AI model

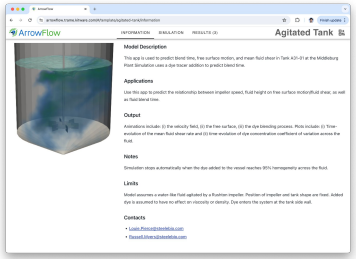
Peacock - Idaho National Laboratory

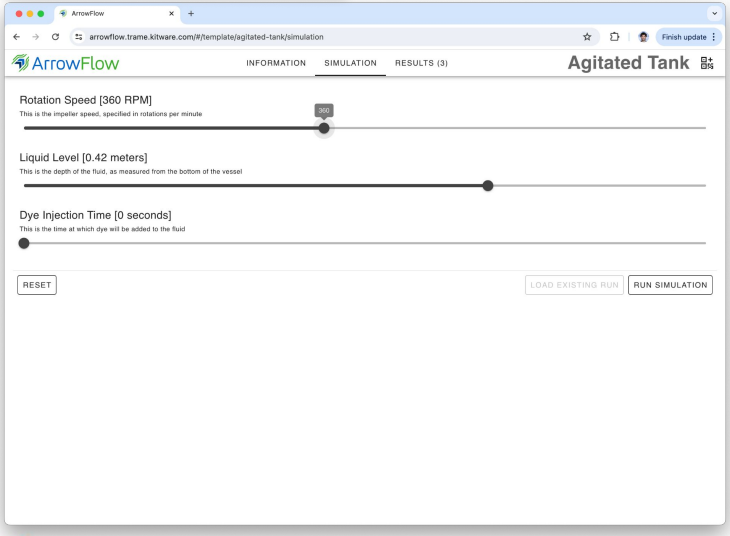


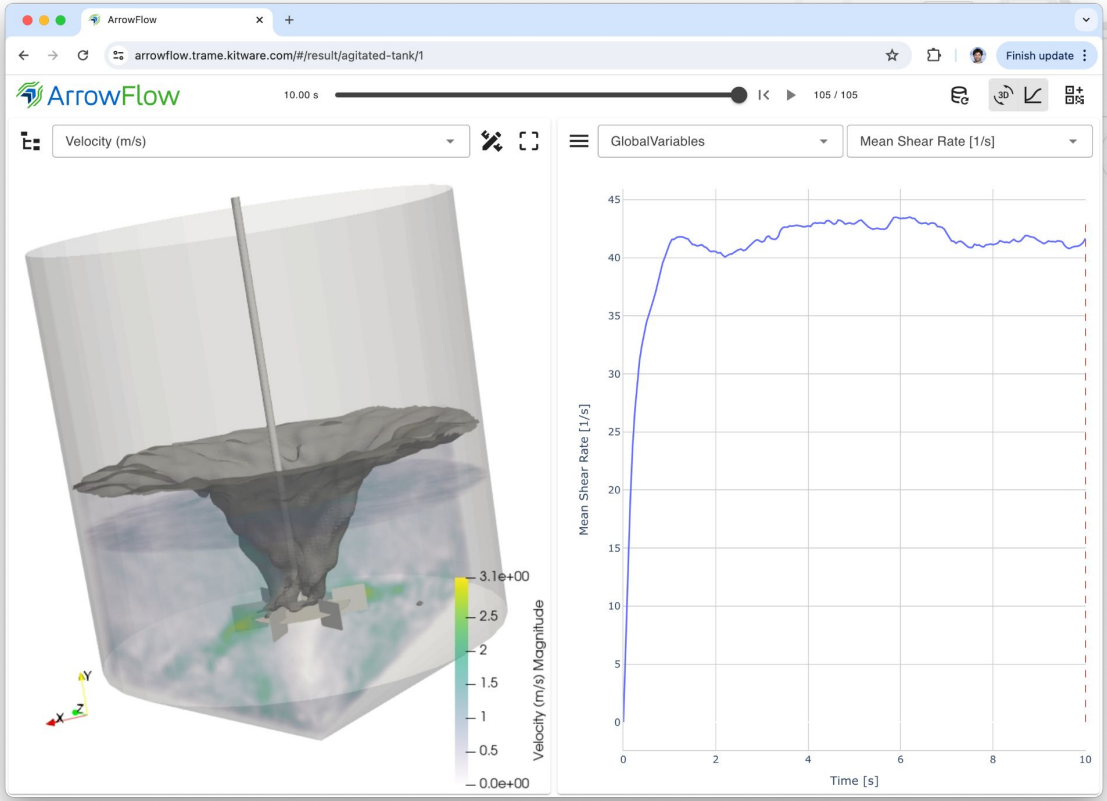
https://github.com/Kitware/peacock

ArrowFlow - Live and templated CFD workflow





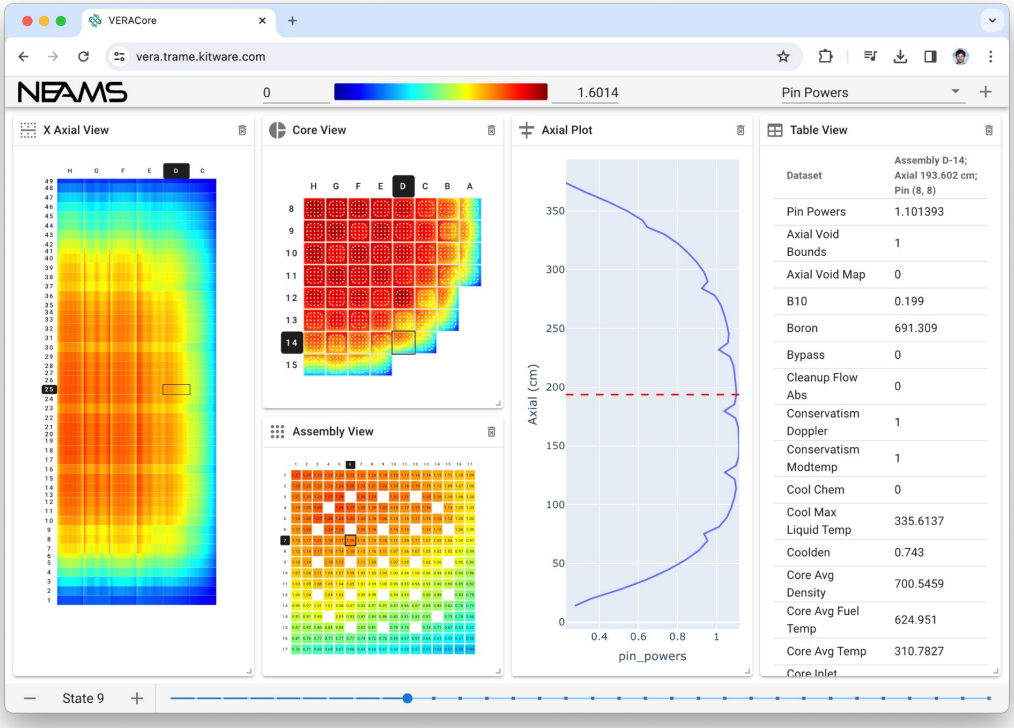


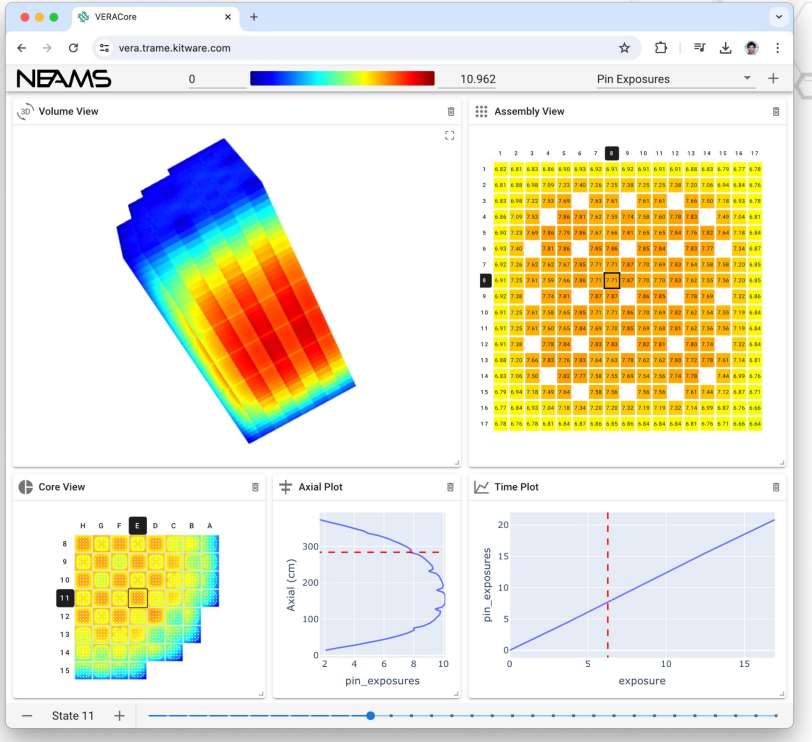


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https://www.kitware.com/arrowflow/

Vera Core - Simulation result exploration

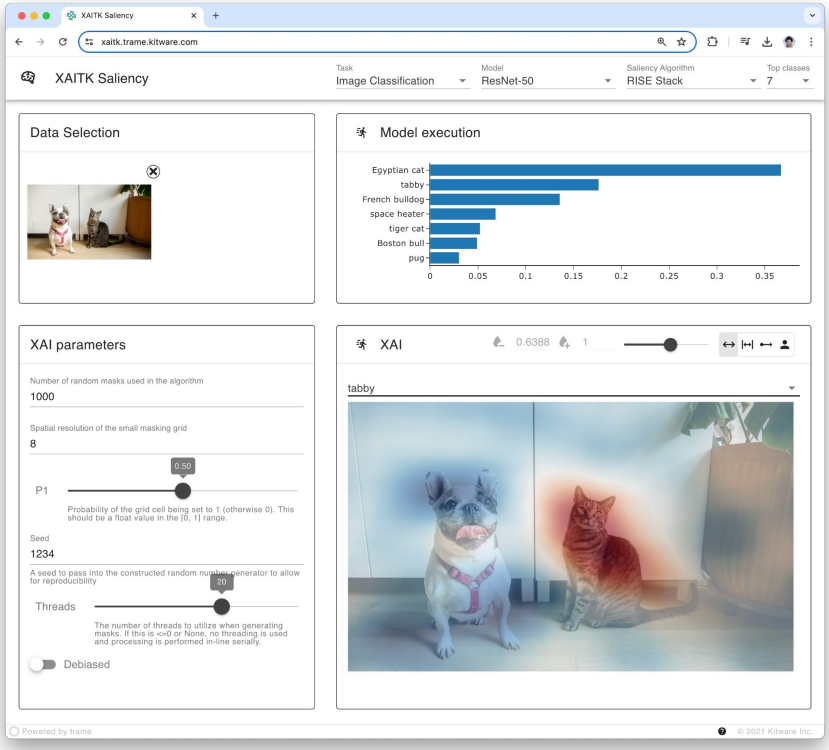


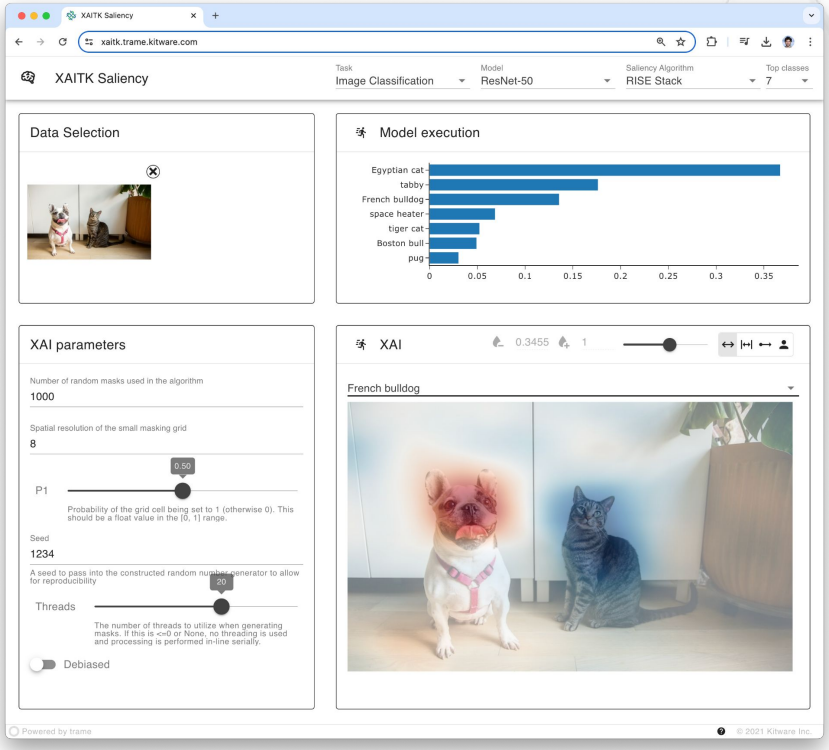


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https://github.com/Kitware/veracore

XAITK - Understanding complex machine learning models

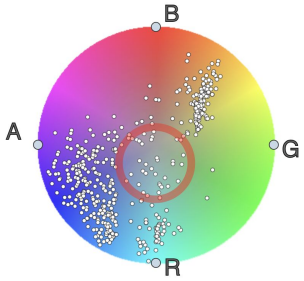


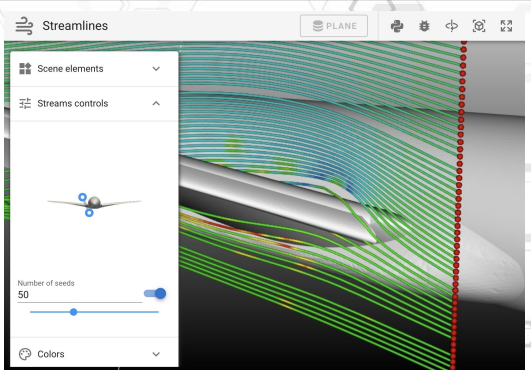


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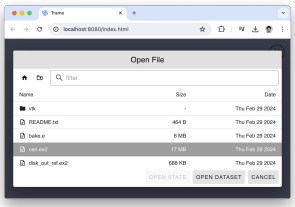
https://xaitk.org/

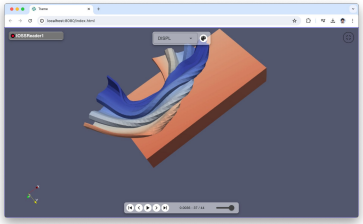
Trame has a lot to offer





- Great for
  - Research, exploration, operational workflows
  - Experiment new UX/UI
- Ubiquitous solution
  - Local, client/server, Jupyter, HPC
- ParaView Trame Components
  - Simple





```python
import ptc

web_app = ptc.Viewer()

with web_app.ui:
  ptc.OpenFileDialog()
  with web_app.col_left:
    ptc.PipelineBrowser()

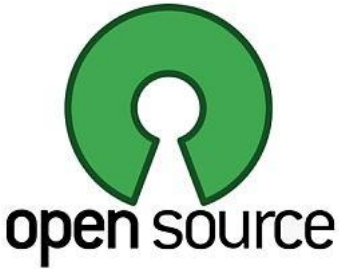
  with web_app.col_center:
    ptc.ColorBy()
    ptc.TimeControl()

web_app.start()
```

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Conclusion

- **VTK and ParaView keep moving forward**
  - You can be part of that evolution
- **Trame expend VTK/ParaView scope**
  - New opportunities and use-cases
- **Open Source**
  - Benefit
    - Help research and discovery
  - Needs
    - Support and funding
    - Try to involve Kitware on the platforms you use so you can focus more on your science



Kitware Services



Training

Learn how to confidently use trame from the expert developers at Kitware.

GET STARTED



Support

Our experts can assist your team as you build your Web application and establish in-house expertise.

GET SUPPORT



Custom Development

Leverage Kitware's 25+ years of experience to quickly build your Web application.

REQUEST A QUOTE

Questions?

Thank you

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