

# Remote Visualization at JSC (with ParaView)

Jülich Supercomputing Centre, Forschungszentrum Jülich GmbH, Germany Algorithms, Tools & Methods Lab Visualization

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Algorithms, Tools & Methods Lab Visualization

#### Scientific Visualization

 R&D + support for visualization of scientific data

#### Virtual/Augmented Reality

 VR visualization based on Unreal Engine, with head mounted displays and tablet computers for data analysis and presentation

#### Multimedia

 multimedia productions for websites, presentations or on TV



#### JUWELS: closer look at login nodes

#### Cluster

#### 4 x Login Nodes with GPU

- juwelsvis.fz-juelich.de
- (juwelsvis00 to juwelsvis03 in round-robin fashion)
- 768 GB RAM each
- 1 GPUs Nvidia Pascal P100 per node
- 12 GB RAM on GPU
- 9 x Login Nodes without GPU
  - juwels-cluster

#### **Booster:**

- 4 x Login Nodes without GPU
  - juwels-booster

**Keep in mind:** software rendering is possible on any node





JURECA-DC: closer look at login nodes

#### 12 x Login Nodes with GPU

- jureca.fz-juelich.de
- (jureca01 to jureca12 in round-robin fashion)
- 1024 GB RAM each
- 2 x Nvidia Quadro RTX8000 per node
- 48 GB RAM on each GPU

**Keep in mind:** software rendering is possible on any node





**General Software Setup** 

#### **Typical Software Stack for Visualization**

**Base Software:** 

X-Server, X-Client (Window-Manager)



Х

OpenGL (libGL.so, libGLU.so, libglx.so), Nvidia or Mesa driver

Middleware:



Xpra

Virtual Network Computing: VNC-Server, VNC-Client

VirtualGL (for remote hardware rendering, if possible)

Parallel and Remote Rendering App, In-Situ Visualization:



ParaView

Other Visualization Packages (more packages on user demand):

Blender, GPicView, VTK, VMD

## **Remote 3D Visualization**



at Jülich Supercomputing Centre

- X forwarding + Indirect Rendering slow, maybe incompatible → bad idea
- "intrinsic remote capable" visualization apps application dependent error-prone setup
- Xpra stream application content with H.264 + VirtualGL easy setup, our recommendation → good idea

## **Remote 3D Visualization**



with X Forwarding + Indirect Rendering

#### Traditional Approach (X forwarding + Indirect Rendering) ssh –X <USERID>@<SERVER>

- uses GLX extension to X Window System
- X display runs on user workstation
- OpenGL command are encapsulated inside X11 protocol stream
- OpenGL commands are executed on user workstation

#### disadvantages

- User's workstation requires a running X server.
- User's workstation requires a graphic card capable of the required OpenGL.
- User's workstation defines the quality and speed of the visualization.
- User's workstation requires all data needed to visualize the 3d scene.
- This approach is known to be error prone (OpenGL version mismatch, ...)

#### Try to **AVOID** for 3D visualization.

# **Remote 3D Visualization**



#### with Xpra + VirtualGL

- X-applications forwarded by Xpra (or VNC) appear on the local desktop as normal windows
- allows disconnection and reconnection without disrupting the forwarded application
- advantages
  - No X is required on user's workstation (X display on server).
  - No OpenGL is required on user's workstation (only images are send).
  - Quality of visualization does not depend on user's workstation.
  - Data size send is **independent** from data of 3d scene.
  - Disconnection and reconnection possible.
- VirtualGL for hardware accelerated rendering: use vglrun <application>
  - it intercepts the GLX function calls from the application and rewrites them.
  - The corresponding GLX commands are then sent to the X display of the 3d X server, which has a 3D hardware accelerator attached.
- Good solution for any OpenGL application

#### https://xpra.org/

## How to use Xpra @ JSC



How to start an Xpra session:

- Recommended way: from JupyterLab@JSC <u>https://jupyter-jsc.fz-juelich.de</u>
  - See next slides
- Alternative: start Xpra session manually
  - Neither recommended nor necessary
  - Just in case you need it: documentation provided on later slides

# Xpra Integration in JupyterLab@JSC



1. Go to <u>https://jupyter-jsc.fz-juelich.de</u> and login



2. Add a new or start an existing JuperLab on JURECA login node or JUWELS vis login node.



# Xpra Integration in JupyterLab@JSC



If needed, start a new launcher by menue: File → New Launcher.
 In the launcher: click on the Xpra icon



4. Wait for the HTML desktop of Xpra. Start apps from the menue or



# Xpra Integration in JupyterLab@JSC



5. Start ParaView in the Xpra environment in your browser, direct access to data stored on HPC filesystem





# ParaView for data visualization

#### **Exercise 1**



- Login to jupyter-jsc.fz-juelich.de
- Start Xpra and ParaView
- Load some data, e.g.

/p/scratch/share/zilken1/ParaView\_HandsOn/ headsq.vti

Lets have some fun with **filters**, see next slides



#### **Common Filters: Contour**

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🕂 View (F	Render View)		



- Extracts the points, curves, or surfaces where a scalar field is equal to a user-defined value.
- This surface is often also called an isosurface



## **Common Filters: Clip**



#### Beware of data explosion:

Structured data is converted to unstructured!



- Intersects the geometry with a user-defined plane, box or sphere
- Removes all the geometry on one side of this plane (box, sphere)



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#### **Common Filters: Slice**

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- Intersects the geometry with a plane, box, sphere or cylinder
- Similar to clipping, except that all that remains is the geometry where the plane is located.





#### **Common Filters: Threshold**

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• Extracts cells that lie within a specified range of a scalar field





#### **Common Filters: Extract Subset**

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🐈 View (Re	ender View)		



 Extracts a subset of a grid by defining a volume of interest and a sampling rate





## **Exercise 2**

Load

/p/scratch/share/zilken1/ParaView\_HandsOn/ disk\_out\_ref2.ex2

 Lets have some fun with filters for vector-data, see next slides



## **Common Filters: Glyph**

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Masking			
Glyph Mode	Every Nth Point		•
Stride	10		
🕂 Displa	y (GeometryRepresent	ation)	
🕂 View (	Render View)		



- Places a glyph, a simple shape, on each point (or subset) in a mesh
- glyphs may be oriented by a vector and scaled by a vector or scalar.





#### **Common Filters: Stream Tracer**

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 Seeds a vector field with points and then traces those seed points through the (steady state) vector field.





## **Common Filters: Warp (vector)**

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Scale Factor	3		
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🐈 View (I	Render View)		



• Displaces each point in a mesh by a given vector field.





## **Calculations within ParaView**

**Calculator**: calculates new attributes based on simple expression

- example: "LANDMASK\*(abs(HGT) + 20.0)"
- Can generate vectors from scalars via "iHat\*velocity\_x + jHat\*velocity\_y + kHat\*velocity\_z"
- Can generate new coordinates
- Unflexibel, no "if" statement

# **PythonCalculator**: calculates new attributes based on simple Python expression

- NumPy and SciPy functions can be used
- Can generate vectors from scalars via "make\_vector (velocity\_x, velocity\_y, velocity\_z)"
- No "if" statement, but numpy.where works, e.g. "numpy.where(Rain > 20, -1 \* Rain, LANDMASK\*(numpy.abs(HGT)+20))"

#### **Programmable Source/Filter**

- Most flexible
- Needs some deeper knowledge of ParaView conventions and data flow



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#### **Filter Menu:**

#### Many more filters in the Filters Menu

Search	Ctrl+Space
Recent	•
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Common	•
Data Analysis	•
Material Analysis	•
Quadrature Points	•
Statistics	•
Temporal	•
Alphabetical	•

- lists of all filters available in • ParaView (Alphabetical)
- state of the entries (enabled/disabled) depends on the current data set's type

Histogram							
Integrate Variables							
Plot Data							
Plot Global Variables	Over Time						
Plot On Intersection (	Curves						
Plot On Sorted Lines			Extract Selection		ParticlePath		Table To Points
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s L	Clean Cells to Grid Clean to Grid I Clip	69 14	Group Datasets Histogram Image Data To AMR		Python Annotation Python Calculator Quadric Clustering Random Attributes	94	Transform Triangle Strips Triangulate
NK SL	Clip Closed Surface Clip Generic Dataset Compute Derivatives		Image Data to Point Set Integrate Variables Interpolate to Quadrature Points		Random Vectors Rectifinear Data to Point Set Rectifinear Grid Connectivity	-	Tube Warp By Scalar Warp By Vector
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s on the	Extract Cells By Region Extract Edges Extract Generic Dataset Surface		Octree Depth Scalars Outline Outline Corners		Stream Tracer With Custom Source Subdivide Surface Flow		
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See https://www.paraview.org/Wiki/ParaView/Users\_Guide/List\_of\_filters ٠

Calculator Extract Selection

Histogram

# **Animating Data**



Using The Animation View, ParaView can animate

- Data time steps (if you have time-dependent data)
- Nearly any property of any pipeline object
- The camera, to perform camera flights along a specified path or orbit.
- Use Python scripts to manipulate the scene every time step





## **Exercise 3**

Load

# /p/scratch/share/zilken1/ParaView\_HandsOn/ can.ex2

Lets have some fun with animations





#### **Questions** ... ?



rendered with Blender from a DNS of a diesel injection spray of ITV, RWTH Aachen University



# Appendix: How to start Xpra manually



#### **Manual Setup of Xpra**

with Xpra + VirtualGL



5. Stop the Xpra session by xpra stop :3

## Manual Setup of Xpra



Step 1: login to a (visualization) login node

#### Linux:

ssh <USERID>@juwelsvis02.fz-juelich.de

#### • Windows:

connect via a ssh client, e.g. PuTTY. The PuTTY ssh keyagent pageant may be usefull, too.





#### Step 2: start xpra on HPC node and notice the displaynumber in the output

#### For example, start an xterm in Xpra:

```
jwvis02> ml Stages/2022 GCCcore/.11.2.0 xpra/4.3.3
jwvis02> xpra start --start=xterm
...
Actual display used: :3
```

• The display-number is needed to connect to the Xpra session

# Setup Xpra



Step 3: connect to Xpra session Install Xpra on your local machine. Download from www.xpra.org

#### Linux: use command

local\_machine> xpra attach
ssh://USERNAME@juwelsvis02.fz-juelich.de/3



4	Session Launcher	-		×
c	Connect to xpra server			
Mode: SSH 🔹	)			
Server: zilken1	iuwelsvis02.fz-juelich.de	22	: 3	
Server Password:				
	Advanced Options			

Page 33

# Setup Xpra



#### Step 4: start visualization application

After successful connection, an xterm window will show up on your local desktop.

Start your application there, e.g. ParaView 5.10.1:



Step 5: When you are done, stop the session by
jwvis02> xpra stop :3