ParaMerlin

Postprocessing Merlin output with Paraview

Prof. Victor E. Saouma

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x-elastica

Acknowledgments

The author would like to thank Mr. Yuichiro Gakuhari for his assistance with some of the more obscure features of Paraview and ensuing documentation.

This program would not have been possible without the development of Merlin by Jan Červenka and accompanying post-processor Spider by Gary Haussmann. Those tools were the primary computational research tool of the author for over 30 years, and the contributions of Jan and Gary is very gratefully acknowledged.

Finally, this software wold not have been as extensively written had it not been for the Covid-19 lock-down which challenged my programming skills over countless hours. It was fun!

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Preface

Merlin (Saouma, Červenka, and Reich, 2010) is a finite element code developed by my group starting 1990[1] and extensively used for various analysis. Merlin generates a binary file `.pst` that is in turn read by Spider (Haussman and Saouma, 2009) which is the accompanying OpenGL/Windows based graphical post-processor.

Whereas it has served well for almost 30 years, time has come to use a better tool to visualize results. The obvious alternative is Paraview.

Hence I undertook the development of ParaMerlin, which is a Matlab®based code that reads the `.pst` file from Merlin and generates `vtk` files ready for Paraview and additional excel (and Matlab®binary) files, Fig. 1.

This document will first describe the structure and operation of Paraview, and then will serve as a guide to the Paraview operation for the resulting `.vtk` files.

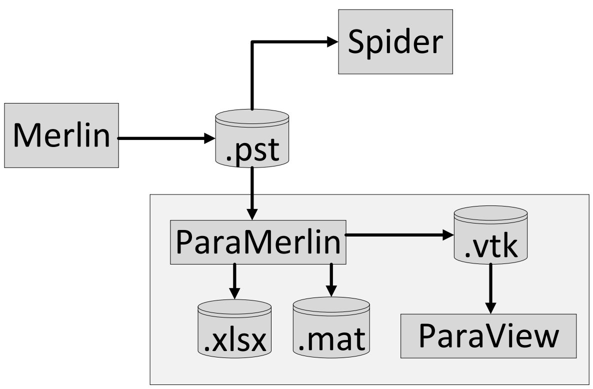


Figure 1: Interconnection among various codes

[1]Originally funded by EPRI, and subsequently by TEPSCO.

1 Execution

1.1 P1_Main

This is the main code that processes the `pst` file, and

- Generate the `vtk` files needed for visualization.
- Creates an Excel file for all the Merlin defined X-Y plots (only the last increment is tabulated, as earlier ones are not needed), §2.2.3.2, Fig. 2.3(a).
- Creates `.mat` files required for subsequent processing of
  - Joints (P_2)
  - Smeared cracks (P_3)
  - Reinforcement (P_4)

To run Paraview you need to create a directory `fn`, without extension where `fn` corresponds to the file name, under the folder `Files`, Fig. 1.1. Then another sub-directory `Input` must be created, and you should copy into it

- the Merlin input file `fn.inp`
- The Merlin generated pst files (there may be multiple ones).

Note that the filename `fn` should not contain a space or an underscore (_).

An excel file storing control parameters must be created, refer to §2.2.2 for a full description.

To execute ParaMerlin, just run the `Main.m` Matlab®code.

Because some file files may be particularly large the user is kept abreast of the various execution steps, Fig. 1.2. Note that ParaMerlin can handle multiple `.pst` files generated by a single analysis, and thise `.pst` may not necessarily output records for each increment.

Output are described in §2.2.3 in conjunction with Fig. 2.1.

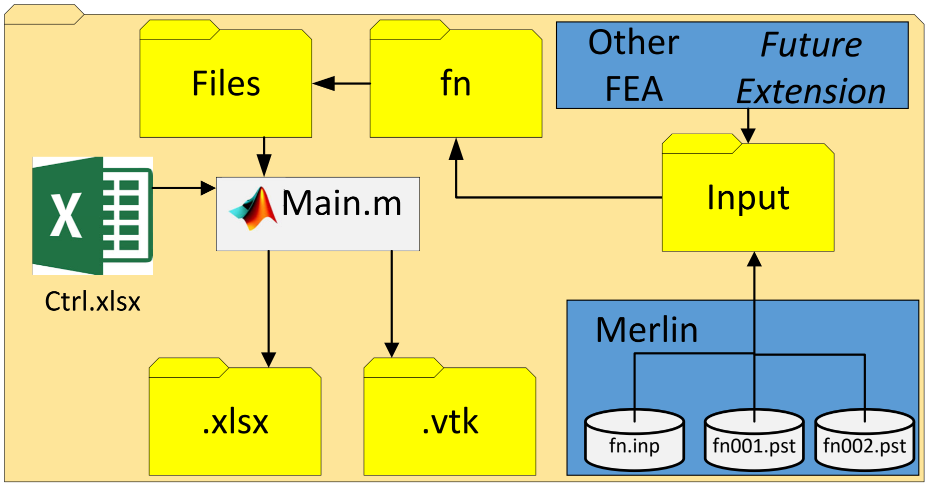


Figure 1.1: Interconnection among various codes

```
pst file Panel.pst; processing psts for record 21 (act increment 59)
pst file Panel.pst; processing psts for record 22 (act increment 62)

File Panel.pst; Eig for Strains Record 51/70 (act Incr 149)
File Panel.pst; Eig for Strains Record 52/70 (act Incr 152)

file Panel.pst; Saving vtk for Record 39/70 (act.  incr.  number 113)
file Panel.pst; Saving vtk for Record 40/70 (act.  incr.  number 116)
```

Figure 1.2: Execution steps

1.2 P2_Joints

Joints are separately processed *after* P_1Main. The code will generate

- Excel file with relevant data §2.2.3.2, Fig. 2.3(b).
- Matlab based plot of all joints Fig. 1.2 where the dots (.) and circles (o) correspond to the `pst` joint variables location and the Merlin corresponding element centroids (they should match).

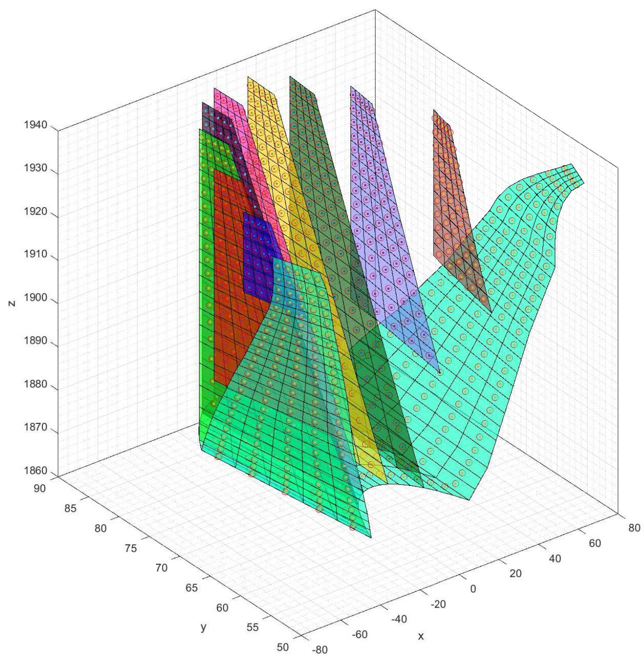
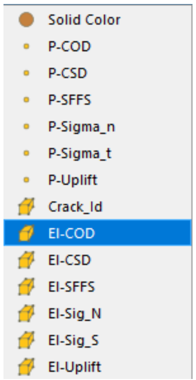
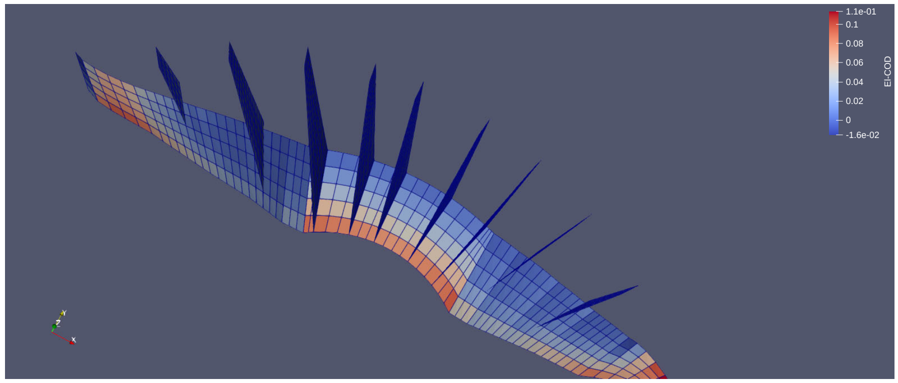


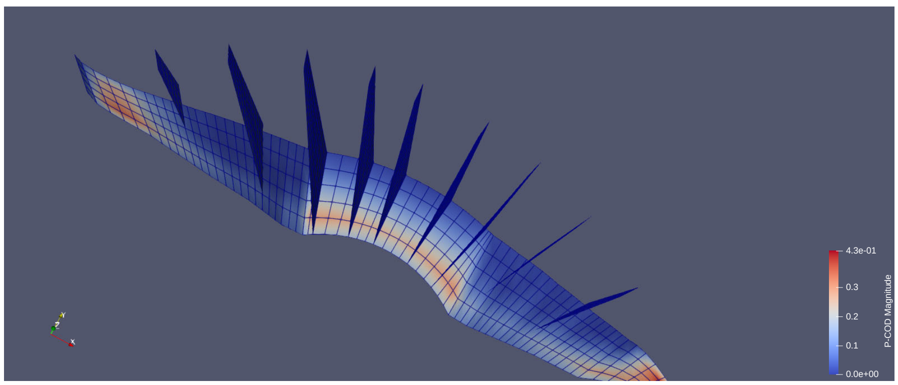
Figure 1.3: Matlab plots generated by by P2_Joints



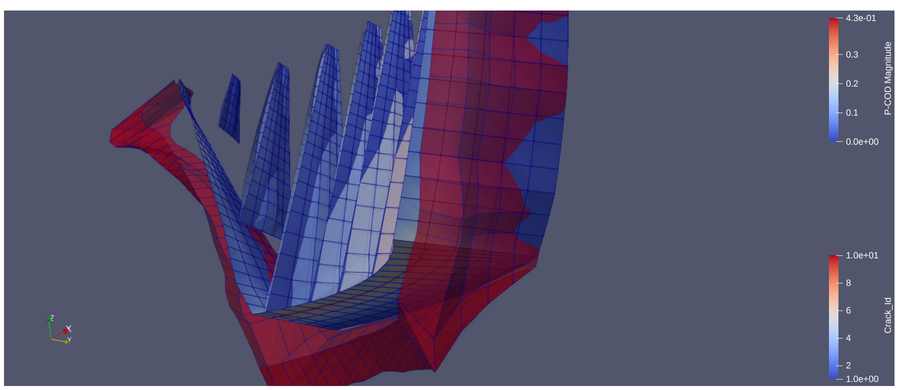
(a) Joint plot options



(b) Joints with element based COD's



(c) Joints with point based COD



(d) Deformed mesh of joints showing CODs

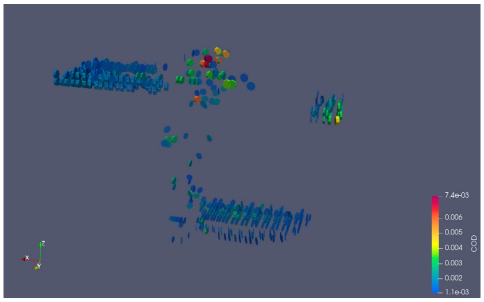
Figure 1.4: Joints vtk visualized with ParaViewProcessed by P2_Joints;

1.3 P3_SC

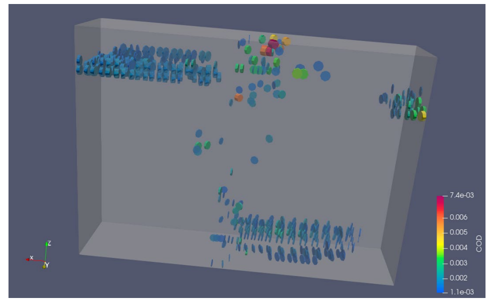
Smeared cracks are processed separately *after* P_1Main. The code will generate

- Excel file with all relevant data, Fig. 3.30(f), §2.2.3.2.

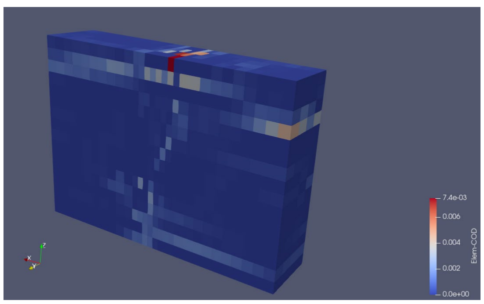
- Separate set of vtk file for the display of smeared crack data Fig. 1.5(a)-1.5(d)
- Histograms of COD's Fig. 1.5(e)



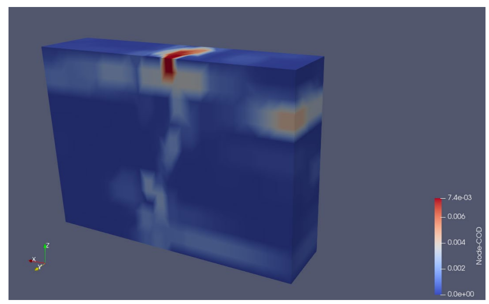
(a) Oriented disks



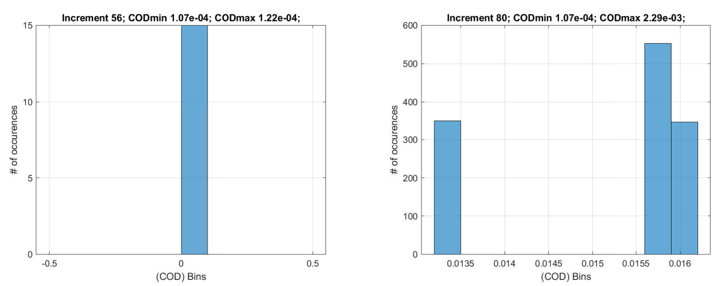
(b) Oriented disks within mesh (need to load two sets of vtks)



(c) Element based



(d) Node based



(e) Historgrams of COD for each increment

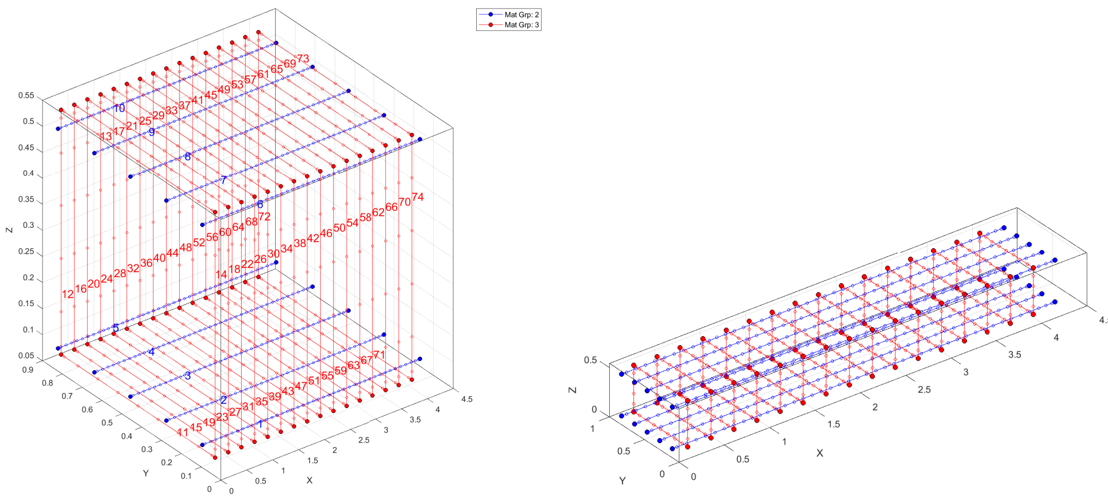
Figure 1.5: Possible displays of smeared cracks

User must specify some controlling parameters as discussed in §2.2.2.

1.4 P4_Reinf

Reinforcements (defined inside Merlin by `ReinfRods` with start end end points) are processed separately *after* P_1Main. The code will generate

- Excel file with all relevant data, Fig. 2.3(d), §2.2.3.2.
- Matlab based plot of reinforcement layout Fig. 1.6.

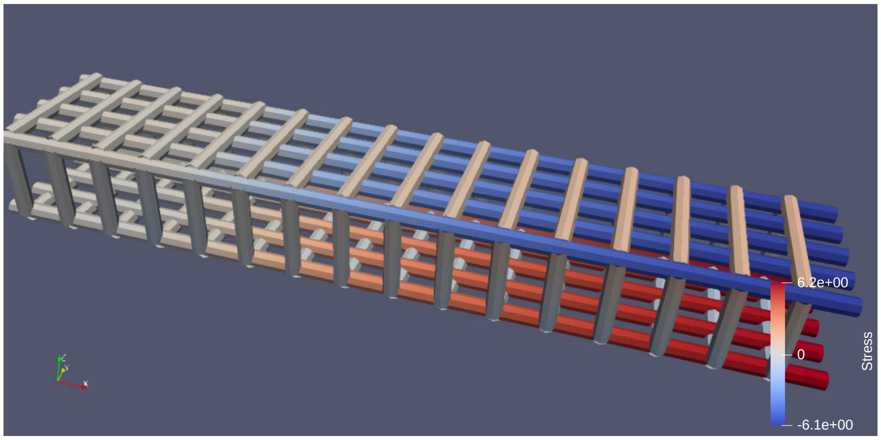


(a) Daspect=0, RefLabel=1 (b) Daspect=1, RefLabel=0

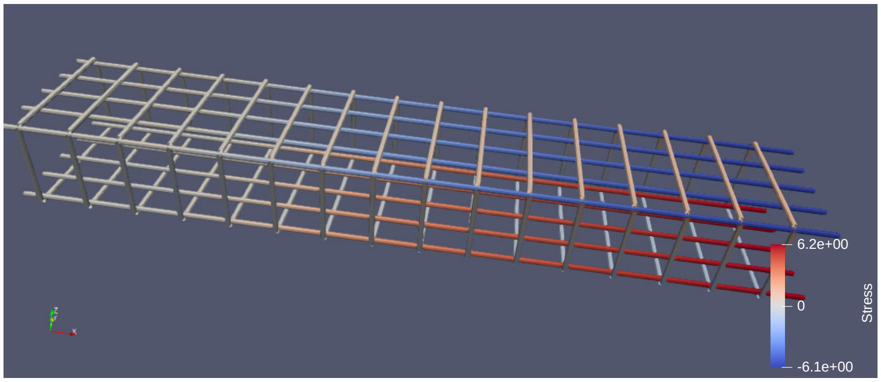
Figure 1.6: Matlab generated display of reinforcement layout

- Separate set of vtk file for the display of reinforcement with computed strains or stresses, Fig. 1.7

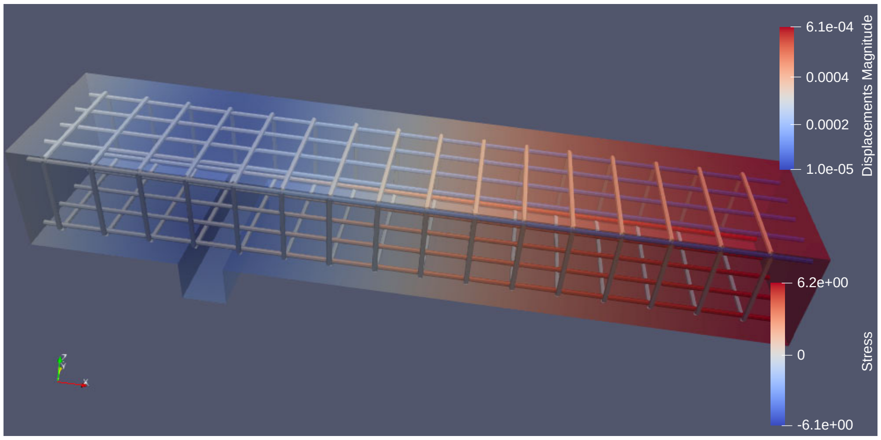
User must specify some controlling parameters as discussed in §2.2.2.



(a) RadFactor=100



(b) RadFactor=300



(c) Reinforcment overlayed with structure

Figure 1.7: Reinforcement displays

2 ParaMerlin, a PreProcessor to ParaView

2.1 Introduction

Once Merlin has completed execution, it will generate one or more `pst` files. those would have to be preprocessed by ParaMerlin.

This chapter will describe the structure and operation of this code.

2.2 Directory Structure

The root folder of the code is illustrated by Fig. 2.1.

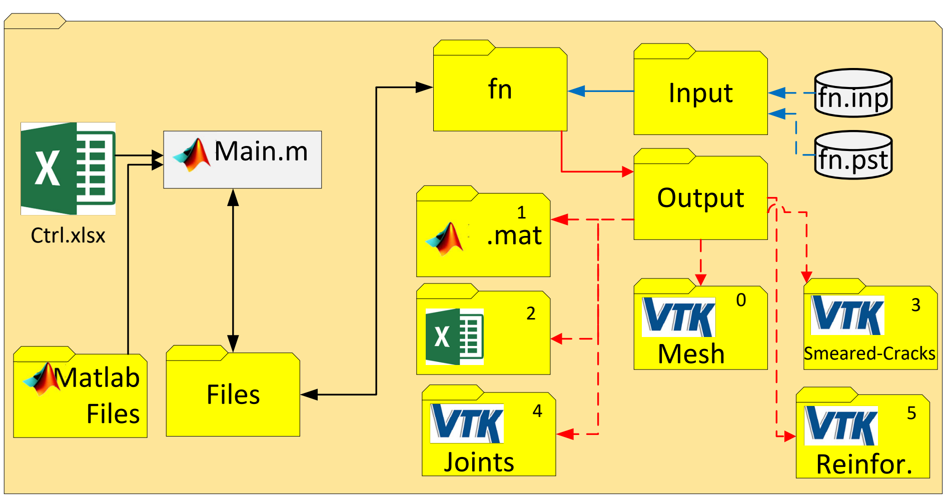


Figure 2.1: Directory structure

The main Matlab®file reads the directives for the excel file `Ctrl.xlsx` (including the file name `fn` and the corresponding input files.

The program will wipe out the corresponding `Output` directory and populates it with place holder for the output.

2.2.1 Input sub-folder

This sub-folder contains only two files assigned by the user

- `fn1.inp`: Merlin input file; note that the filename must correspond to the name of the parent directory.
- `fn1.pst`: Merlin `.pst` file

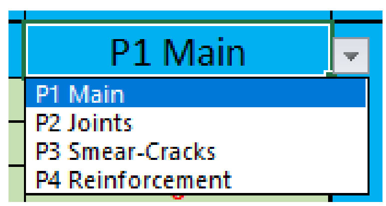
When first executed, ParaMerlin will generate a `fn.dat` file which is an ASCII copy of the binay `.pst` file.

2.2.2 Ctrl Excel File

`P1_vtk_4_mesh.m` is the main file that generates the `vtk` files for the finite element mesh, and should be the first one to be executed. Input data parameters are read from the excel file `Ctrl.xlsx`, Fig. 2.2

1	Filename	rc	
2	What do you want to process?	Reinforcement	For P1 Main
3	Ascii or Binary	ASCII	
4	Compute Eigenvalues	1	
5	Write joint data on Excel	0	
6	PlotHist	1	For P3 Smeared Cracks
7	Write smeared cracks COD on Excel	1	
8	Generate smeared crack disks	1	
9	nbins	10	
10	ScalThick	1.00E-03	
11	MinVisThick	1.00E-03	
12	Transp	1	
13	FracR	0.7	
14	CODfrmt	%.2e	
15	Matlab plots reinforcement layout	0	For P4 Reinforcement
16	RefLabel	1	
17	Daspect	0	
18	Matlab plot Reinf stress-strain	1	
19	Write Reinf data on Excel	1	
20	RadFactor	300	

(a) Control File



(b) Pull-Down menu for execution

Figure 2.2: User defined Excel input file

1. File name (no space, no underscore (_), no extension (those are only allowed in the Merlin generated `.pst` files)
2. Flag to select program to execute. Note that P_1 Main will wipe out previous output directory.
3. VTK output format (ascii or binary)
4. Flag to control calculation of eigenvalues/eigenvectors (note that this can also be doe with the `tensor Glyph` filter in Paraview
5. Flag to direct storing joint data in an excel file*

6. Flag to direct plot of COD histograms for each increment
7. Flag to output smeared crack COD data on an excel file*
8. Flag to direct generation of smeared crack oriented disks (vtk files)
9. Number of bins for the COD histograms
10. Scaling factor for the smeared crack disks
11. Size if the smallest visible smeared crack
12. Transparency of the oriented disks
13. Scaling factor for the radius (equal to the element size)
14. Format of the COD numerical value in histograms
15. Flag to plot all reinforcement through Matlab pre-processing
16. Flag to label the reinforcement in the Matlab plot
17. Flag to set the Matlab plot aspect ratio to the exact one
18. Flag to plot all reinforcement stress and strain on separate pdf files
19. Flag to write reinforcement data on an excel file
20. number to adjust diameter of rebars in paravie (radius would be equal to the maximum dimension divided by RadFactor)

* those excel files may be necessary to determine damage indicators (DI)

Again, if the root file is being processed, it will wipe out all the previously generated `vtk`, `mat` and `.xlsx` files.

Similarly, processing the smeared cracks or the joints is contingent upon having previously processed the root file.

The processed file name `fn` should not include an underscore (_) or a blank space in its name.

2.2.3 Output sub-folder

The output sub-folders are shown in Fig. 2.1 where full names are not shown; only descriptive ones, along with the ID identifier.:

- `0-VTK-Files`: Finite element mesh, one vtk per increment
- `1-mat-files`: Various Matlab®binary files for subsequent use, Table 2.1:
- `2-Excel-Files` Excel file with: 1) all user specified X-Y plots; 2) joint 3) smeared crack and 4) Reinforcing bars strains and stresses data.
- `3-smeared-cracks-vtk` Smeared crack (disks) only
- `4-joints-vtk` Joints only

- 5-Reinf-vtk reinforcement only

2.2.3.1 Output: fn.mat files

Each .pst file will generate a corresponding .mat file that contains the following structures

Mesh stores element connectivity and nodal , Table 2.2

Increment_ID Relevant when multiple .pst files are generated.

pstData stores nodal values, Table 2.3 where

nDim	Spatial dimension [2—3]
nIncr	Number of increments
nnodes	Number of nodes

Note that the labels may change depending on the type of analysis. The components are cell array containing the componenet labels, such as
Disp_x, Disp_y Disp_z.

Other .mat files that are to be read

- fn_XXX-JointData.mat input file for P2_vtk_4_joints.m
- fn_XXX-Reinf.mat Currently unused, contains reinforcement strains and stresses.
- fn_XXX-SmearCrack.mat input file for P3_vtk_4_sm_cracks.m

2.2.3.2 Excel Files

There are two categories of excel file:

- Those corresponding to the user specified incremental plots in Merlin. Results for the last increment will be tabulated along with the proper heading, Fig. 2.3(a).
- Those generated by processing the .pst files :

Table 2.1: .mat files

File	Processed by	Leads to
fn.mat	P1_Main.m	0-VTK-Files
fn.JointData.mat	P2_Joints.m	4-joints-vtk
fn.SmearCrack.mat	P3_SC.m	3-smeared-cracks-vtk
fn-Reinf.mat	P4_Reinf	5-Reinf-vtk

Table 2.2: `Mesh.` structure array

`Mesh.Analysis`	Type of analysis (Displacement, Heat, Dynamic or AAR)
`Mesh.NGroups`	Number of different element groups
`Mesh.Groups`	Element types, and material types associated with each element.
`Mesh.nnodes`	Number of nodes
`Mesh.NCornernodes`	Number of nodes
`Mesh.Dimen`	[2—3]
`Mesh.nelem`	Number of elements
`Mesh.MaxnumNode`	Maximum number of nodes
`Mesh.Node`	Coordinates of each node
`Mesh.Elem`	For each element: type, group and connectivity

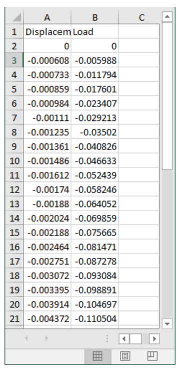
Table 2.3: `pstValues` structure array

Order	Label	Component	Values
nDim	Prin-Strains-Min	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Strains-Inter	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Strains-Max	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Stresses-Min	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Stresses-Inter	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Stresses-Max	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Plastic_strains-Min	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Plastic_strains-Inter	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-Plastic_strains-Max	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-AAR_strains-Min	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-AAR_strains-Inter	nDim cell	nIncr×nnodes×nDim double
nDim	Prin-AAR_strains-Max	nDim cell	nIncr×nnodes×nDim double

– `fn_XXX-JointData.mat` processed by `P2_joints.m` and generate: `Crack-x-Data.xlsx` where x correspond to the Merlin defined crack number, Fig. 2.3(b). Each incremental set of data will be saved in a corresponding sheet.

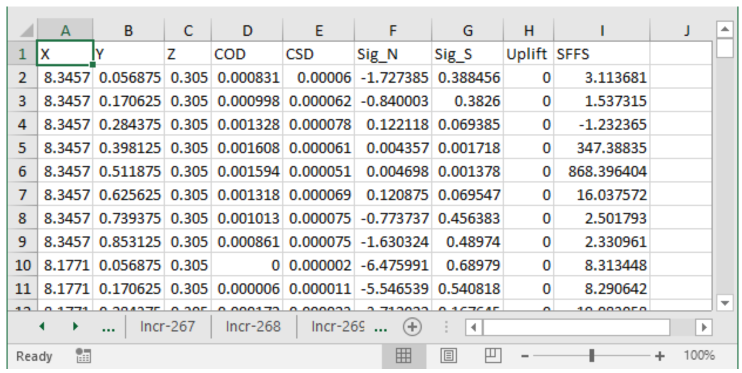
– `fn_XXX-SmearCrack.mat` processed by `P3_SC.m` and generate: `SC-COD.xlsx` Fig. 2.3(c). Each incremental set of data will be saved in a corresponding sheet.

– `fn_XXX-rc-Reinf.mat` processed by `P4_Reinf.m` and generate: `Reinf.xlsx` Fig. 2.3(d). The (material) group, end points coordinates, length and distance from first node are shown in columns A-J, then results for all increments are tabulated in the subsequent columns. The same sheet contains data for all reinforcements (separated by a blank line). One sheet contains strains, the other the stresses.



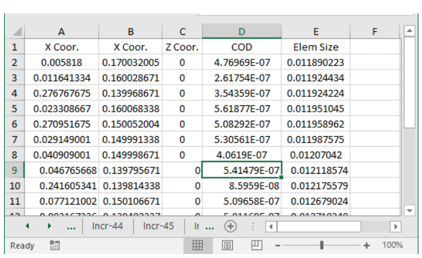
	A	B	C
1	Displacem	Load	
2	0	0	
3	-0.000608	-0.005988	
4	-0.000733	-0.011794	
5	-0.000859	-0.017601	
6	-0.000984	-0.023407	
7	-0.00111	-0.029213	
8	-0.001235	-0.03502	
9	-0.001361	-0.040826	
10	-0.001486	-0.046633	
11	-0.001612	-0.052439	
12	-0.00174	-0.058246	
13	-0.00188	-0.064052	
14	-0.002024	-0.069859	
15	-0.002188	-0.075665	
16	-0.002464	-0.081471	
17	-0.002751	-0.087278	
18	-0.003072	-0.093084	
19	-0.003395	-0.098891	
20	-0.003914	-0.104697	
21	-0.004372	-0.110504	

(a) Merlin



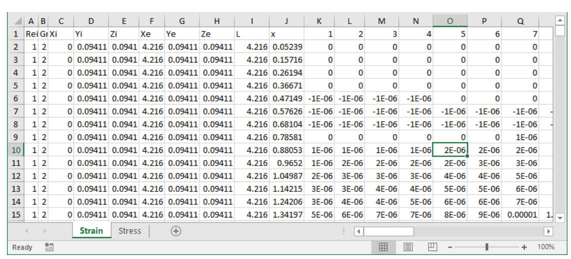
	A	B	C	D	E	F	G	H	I	J
1	X	Y	Z	COD	CSD	Sig_N	Sig_S	Uplift	SFFS	
2	8.3457	0.056875	0.305	0.000831	0.00006	-1.727385	0.388456	0	3.113681	
3	8.3457	0.170625	0.305	0.000998	0.000062	-0.840003	0.3826	0	1.537315	
4	8.3457	0.284375	0.305	0.001328	0.000078	0.122118	0.069385	0	-1.232365	
5	8.3457	0.398125	0.305	0.001608	0.000061	0.004357	0.001718	0	347.38835	
6	8.3457	0.511875	0.305	0.001594	0.000051	0.004698	0.001378	0	868.396404	
7	8.3457	0.625625	0.305	0.001318	0.000069	0.120875	0.069547	0	16.037572	
8	8.3457	0.739375	0.305	0.001013	0.000075	-0.773737	0.456383	0	2.501793	
9	8.3457	0.853125	0.305	0.000861	0.000075	-1.630324	0.48974	0	2.330961	
10	8.1771	0.056875	0.305	0	0.000002	-6.475991	0.68979	0	8.313448	
11	8.1771	0.170625	0.305	0.000006	0.000011	-5.546539	0.540818	0	8.290642	

(b) Joint



	A	B	C	D	E	F
1	X Coor.	X Coor.	Z Coor.	COD	Elem Size	
2	0.005818	0.170032005	0	4.76969E-07	0.011890223	
3	0.011641334	0.160028671	0	2.61754E-07	0.011924434	
4	0.276767675	0.139968671	0	3.54359E-07	0.011924224	
5	0.023308667	0.160068338	0	5.61877E-07	0.011951045	
6	0.270951675	0.150052004	0	5.08292E-07	0.011958962	
7	0.029149001	0.149991338	0	5.30561E-07	0.011987575	
8	0.040909001	0.149998671	0	4.0619E-07	0.01207042	
9	0.046765668	0.139795671	0	5.41479E-07	0.012118574	
10	0.241605341	0.139814338	0	8.5959E-08	0.012175579	
11	0.077121002	0.150106671	0	5.09658E-07	0.012679024	

(c) Smeared crack



(d) Reinforcement

Figure 2.3: Excel files generated by ParaMerlin

3 ParaView

3.1 General Operations

3.1.1 User Interface

The User interface is composed of four parts, Fig. 3.1. Note that whenever you load a file (or sets of files), you would need to click on the Apply icon. To clear the display, you would have to ckick on the fifth icon. Displayed is the surface without the mesh, to view the mesh, you would select “Surface with Edges”, for the nodes, you would select “Point Gaussian”.

The displayed is rendered for the magnitude of the displacements (you could opt for individual components). You can select any of Merlin specified vectors for rendering.

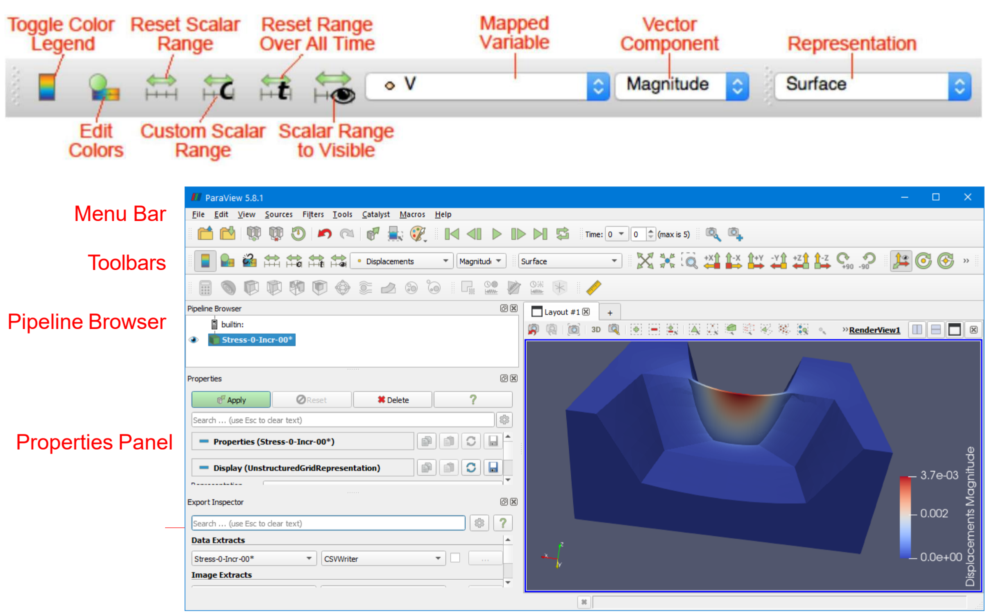
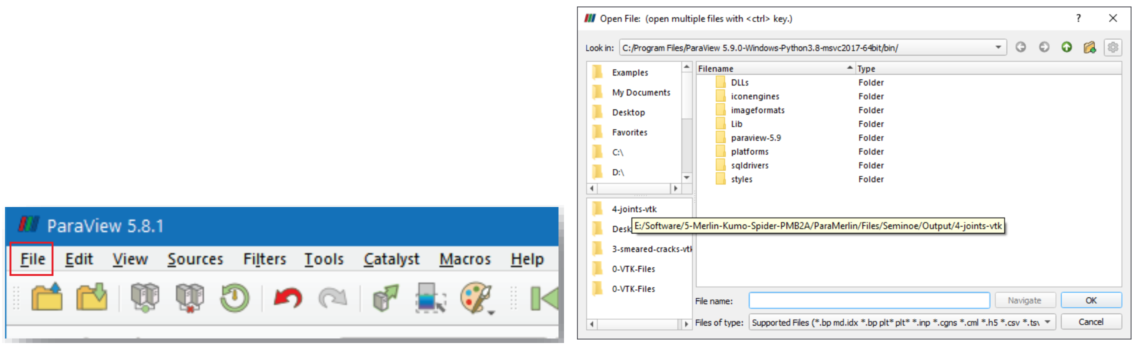


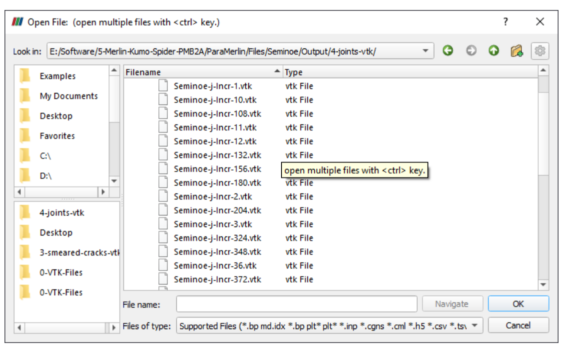
Figure 3.1: User interface

3.1.2 Select File

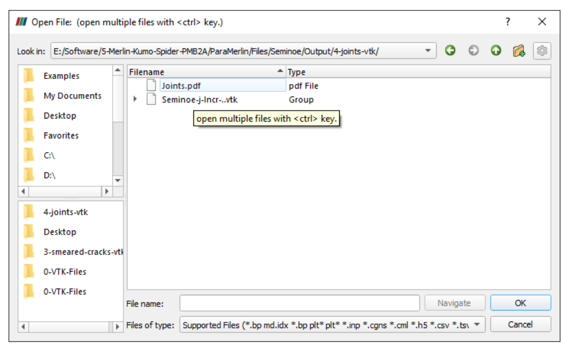
The process of selecting files is illustrated in Fig. 3.2. It is important to note that in Paraview, each increment (or time step) will have its own `vtk` file. When selecting files, Paraview can identify a series of incremental file group (by identifying similar filenames with an integer somewhere that appears to correspnd to a time increment), and select all of them in one single selection. Or use may select only one of them.



(a) Select file menu



(b) Select individual file



(c) Select file series (time history/increments) files

(d) Confirm

Figure 3.2: File selection

3.1.3 Mapped variable

Mapped variable is one of those specified by the vtk files at the node or cell levle, Fig. 3.3.

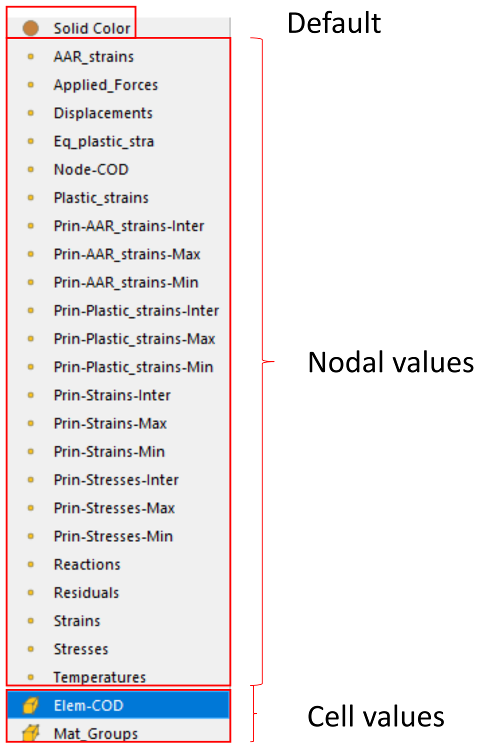


Figure 3.3: Mapped variables

3.1.4 Pipeline browser

Each time to select a new display, Paraview creates a new graphical display which can be viewed, along with all previous ones, in the Pipelin browser, Fig. 3.4. You may activate view of multiple (and thus superimposed) displays. FOr instance you may display the original mesh with an opacity less than one, and superimpose on it the display of the deformed mesh.

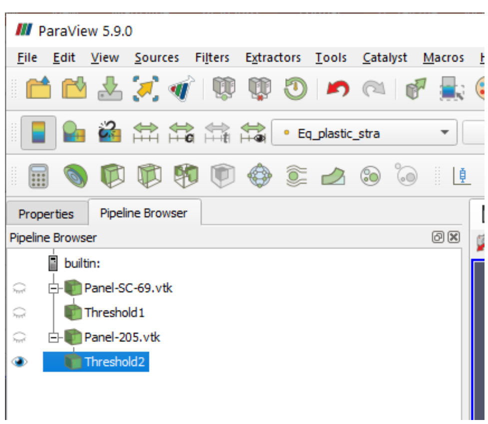


Figure 3.4: Pipeline browser

3.1.5 Background Color

Background color can be altered, Fig. 3.5.

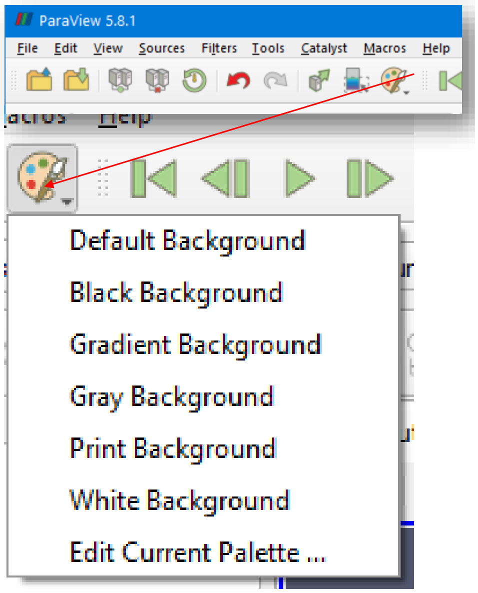


Figure 3.5: Background color

3.1.6 Mesh display

User may select one of many different representations of the mesh, Fig. 3.6.

3.1.7 Display Properties

Display properties, Fig. 3.7: of particular relevance is the "Opacity" to make a mesh transparent. Note that more options can be selected if you click on the "setting icon" in the upper right.

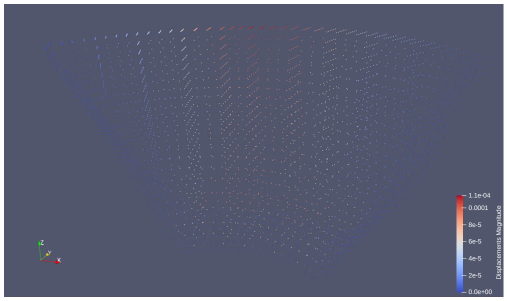
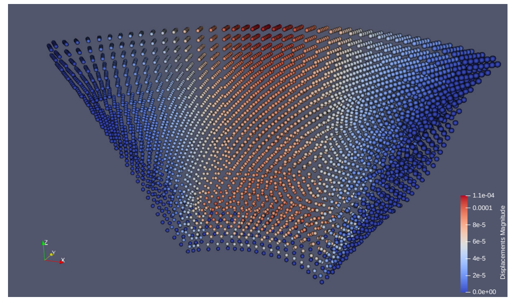
3.1.8 Moving Objects

Moving objects can be achieved either by mouse operation:

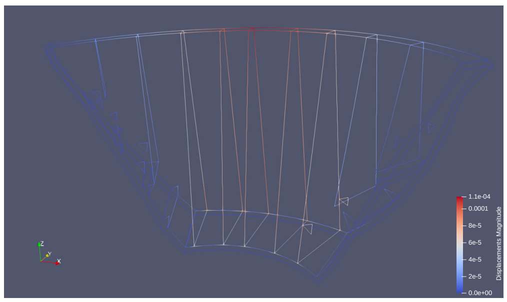
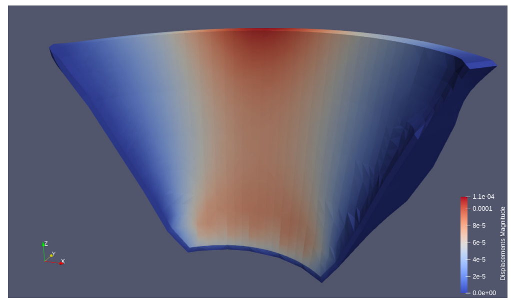
- Rotate: Mouse left button
- Scale: Mouse right button
- Translate: Mouse center button

or from te bar for "quantum" operations.

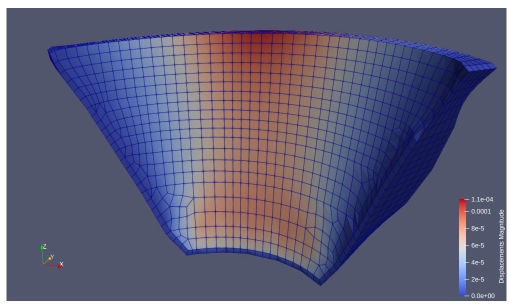
Likewise, you may undo and redo basic operations.

(a) Point (b) Point Gaussian

(c) Wire frame (d) Surface



(e) Surface Edge

Figure 3.6: Possible views

3.1.9 Opacity

Mesh can be made transparent by seleecting the opacity of the display, Fig. 3.9.

3.1.10 Sharpen Contrast

You can sharpen contrast by clicking on Edit in the coloring menu and then select Interpret values as categories, Fig. 3.10. Note that in this figure annotation (of material ID in this case) was added.

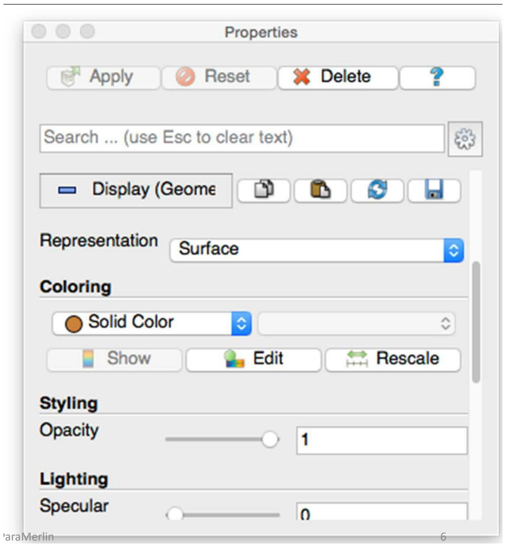


Figure 3.7: Display properties

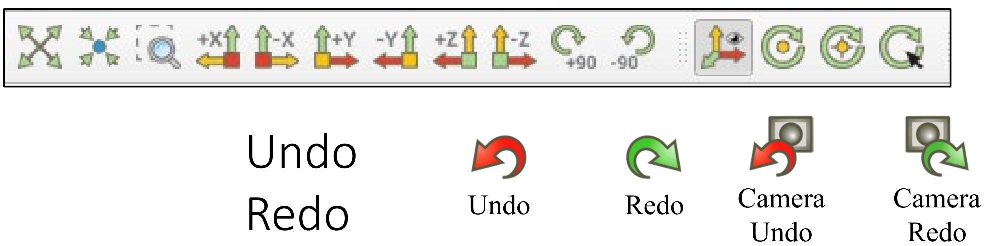


Figure 3.8: Moving object

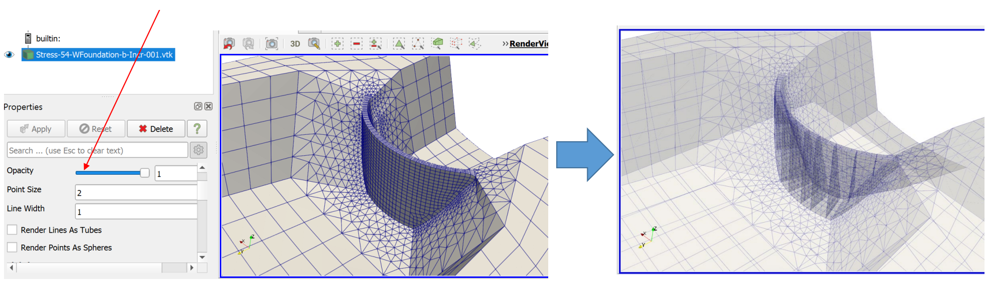


Figure 3.9: Adjusting opacity

3.1.11 Data Representation

Data representation 3.11

Most important ones are the Mapped variable, the vector component and the representation itself (surface, surface with edges, Point Gaussian or wireframe.

3.2 Filters

3.2.1 Common filters

Common filters are shown in Fig. 3.12

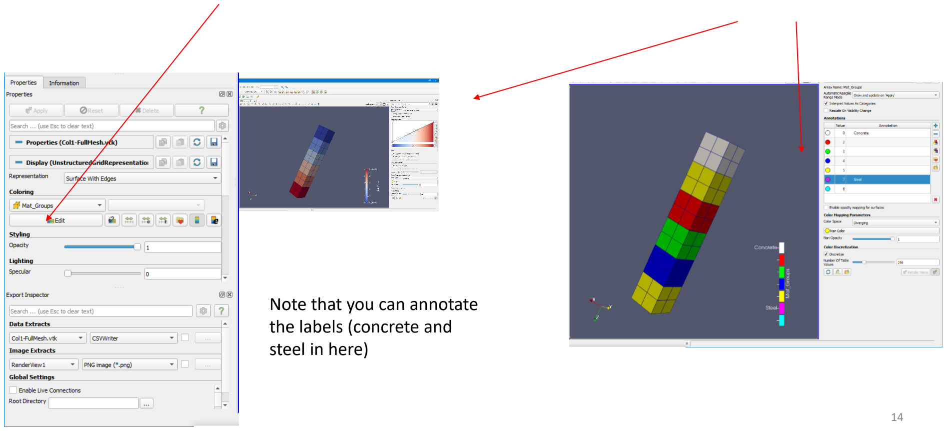


Figure 3.10: Sharpen contrast

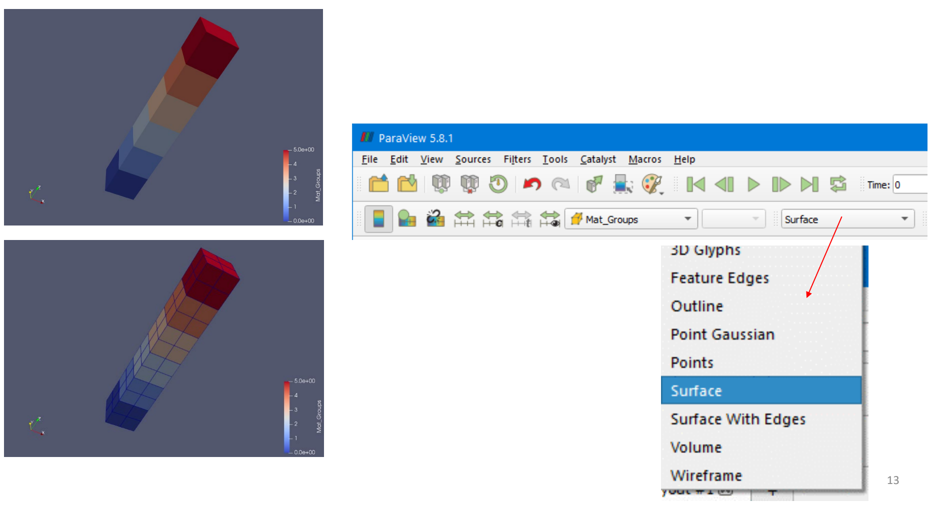


Figure 3.11: Data representation

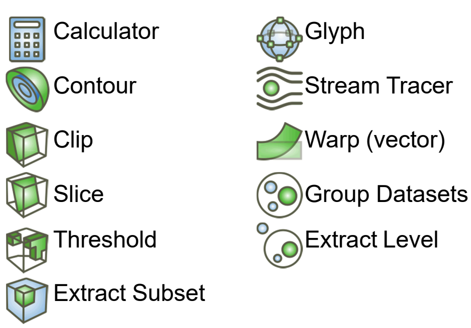


Figure 3.12: Common filters

3.2.2 Find data that match

You can find data that match certain criteria by

1. Edit-¿Find Data,
2. Click on either point or cell data
3. Click on the variable name
4. Click on criteria Fig. 3.13

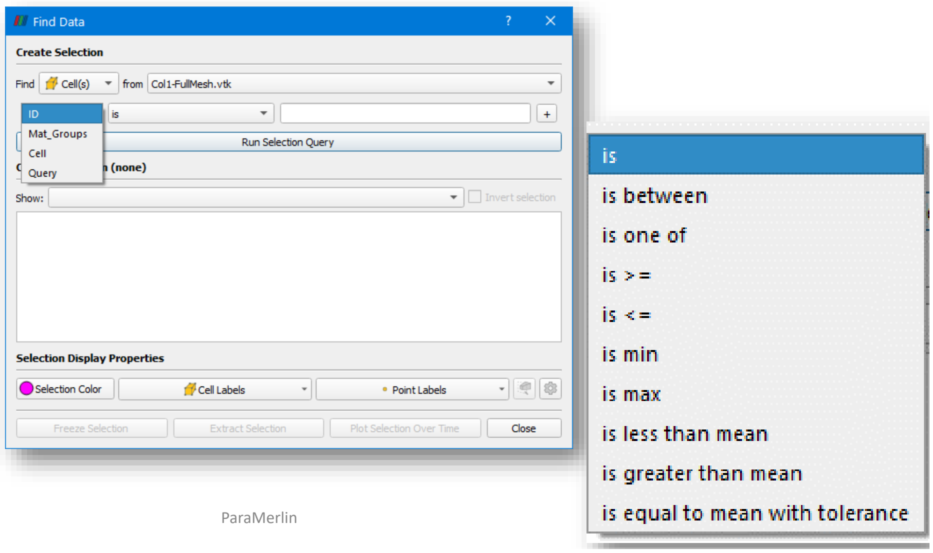


Figure 3.13: Selection criteria for find data

5. Run Selection Query (data will be displayed in a table)
6. Extract Selection, and then Apply to change the view of only cells/points that meet the criteria, Fig. 3.14

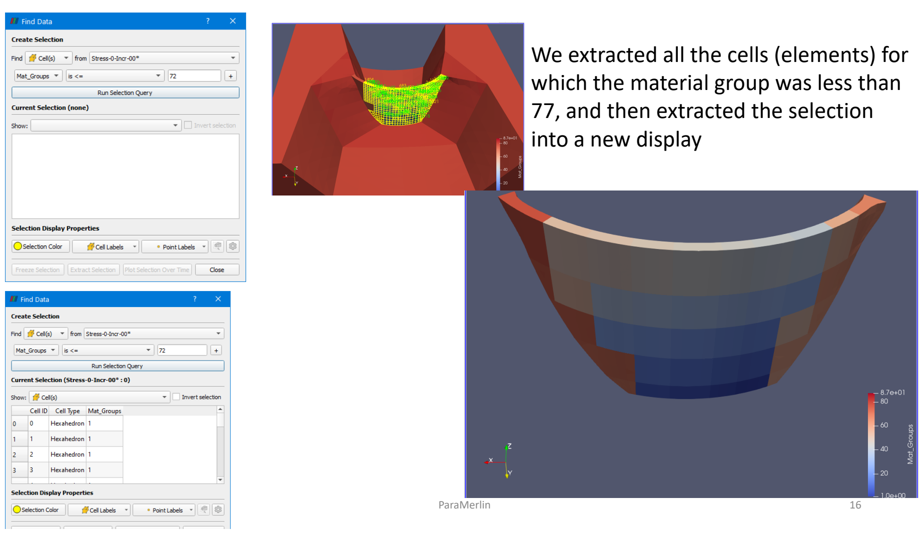


Figure 3.14: Extracted mesh

3.2.3 Clip mesh

 Display can be clipped by selecting clip plane, Fig. 3.16

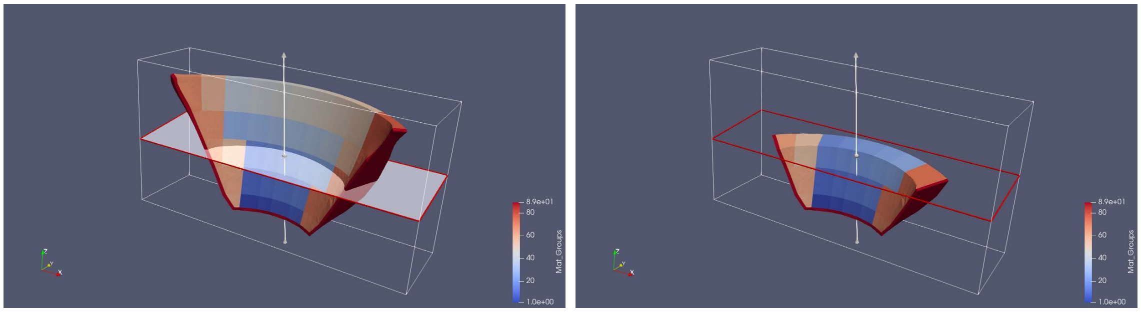


Figure 3.15: Clip mesh

3.2.4 Slice mesh

Display can be clipped by selecting clip plane, Fig. 3.16

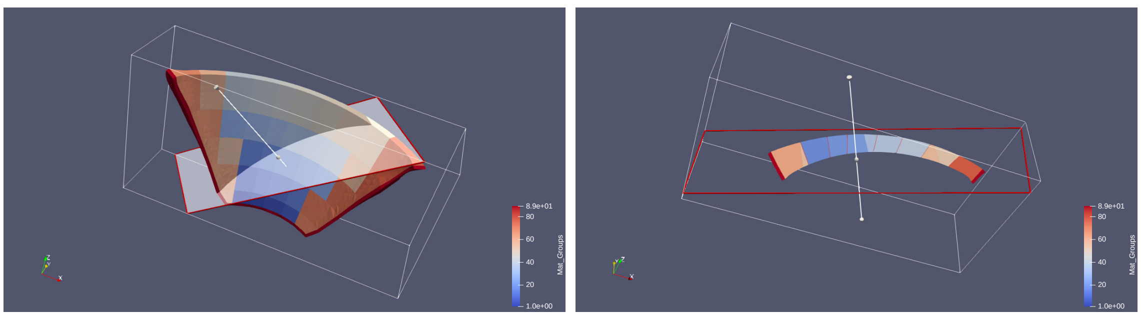


Figure 3.16: Clip mesh

3.2.5 Find data

You can find selected nodes that meets a certain criteria, Fig. 3.17

3.3 Select display

3.3.1 Threshold

You may use the Threshold filter to display cells within a minimum and a maximum, Fig. 3.18-3.19

In doing so, Paraview will either delete elements outside the range, or reverse, just keep elements within it.

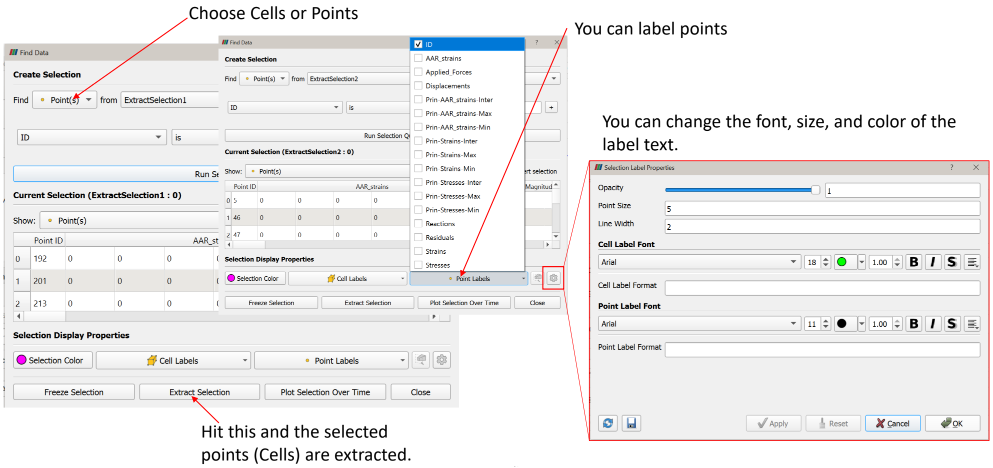


Figure 3.17: Find data

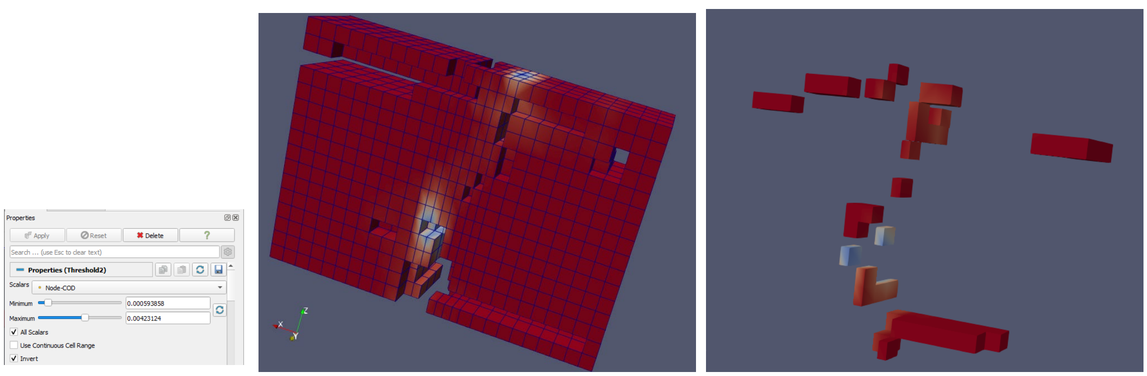


Figure 3.18: Threshold display of elements meeting certain conditional values

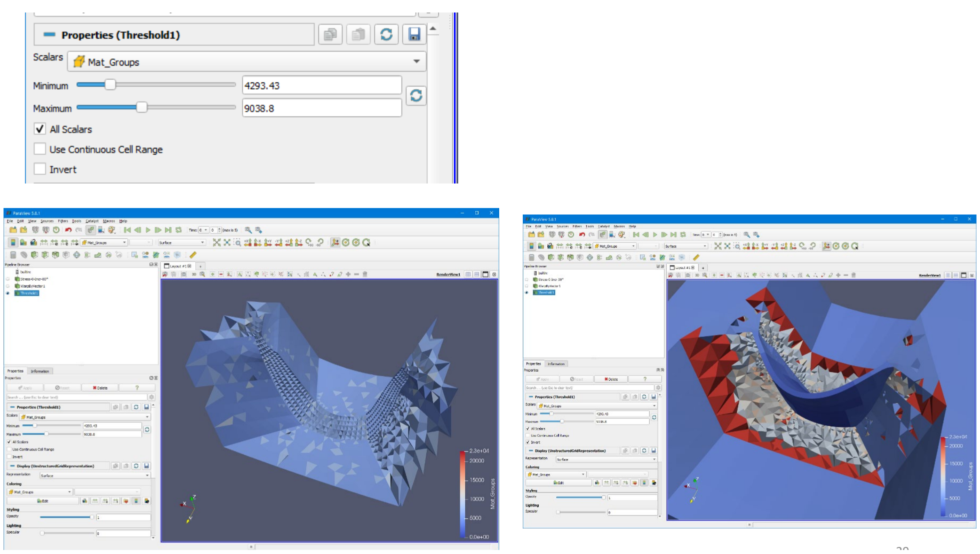
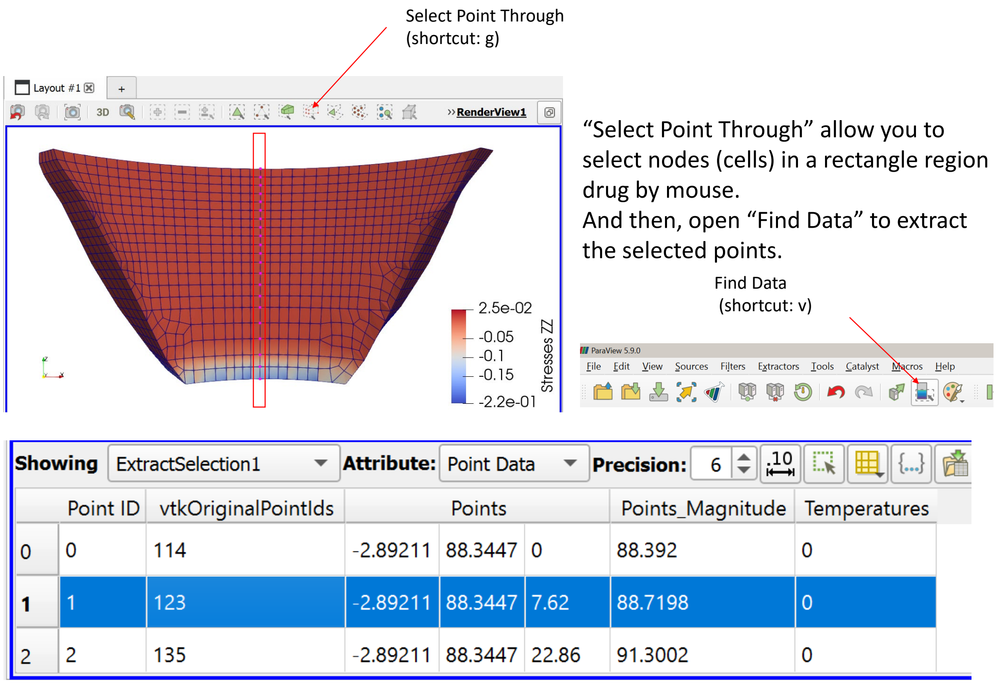


Figure 3.19: Threshold display of selected element groups

3.3.2 Extract selection

You may use the Threshold filter to display cells within a minimum and a maximum, Fig. 3.20. Careful, if you extract selection, node IDs are renumbered. However you may still view original ones in the spreadsheet view under "vtkOriginalPointids".



	Point ID	vtkOriginalPointIds	Points			Points_Magnitude	Temperatures
0	0	114	-2.89211	88.3447	0	88.392	0
1	1	123	-2.89211	88.3447	7.62	88.7198	0
2	2	135	-2.89211	88.3447	22.86	91.3002	0

Figure 3.20: Extract selection

3.3.3 Integration

Integration over a surface can easily be performed, Fig. 3.21. Note that integration over a volume is also possible.

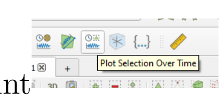
3.3.4 Spatial data analysis

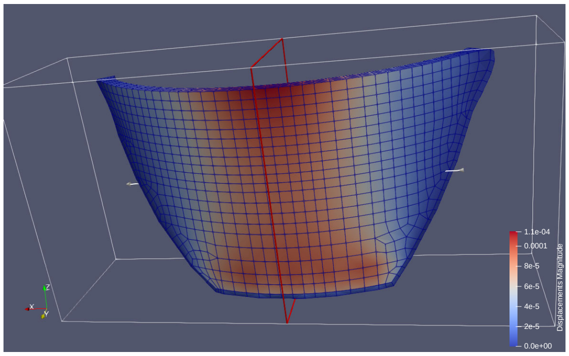
You can plot data between two arbitrary points, Fig. 3.22(a).

File-¿Data Analysis-¿Plot over line. You may then use the cursor to adjust location of end points (intersection of mesh and line), and then under x-axis Properties, select which variable to display along the y axis.

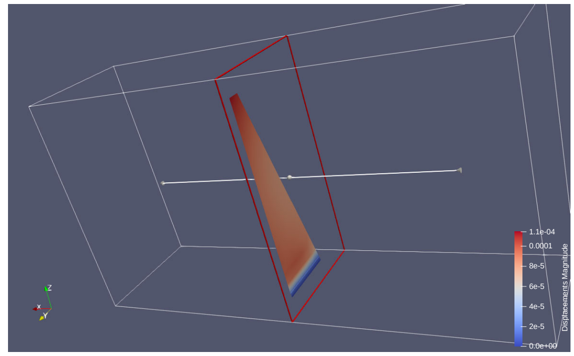
At first all parameters are plotted, you can then select those of interest, Fig. 3.22(b).

3.3.5 Temporal data analysis

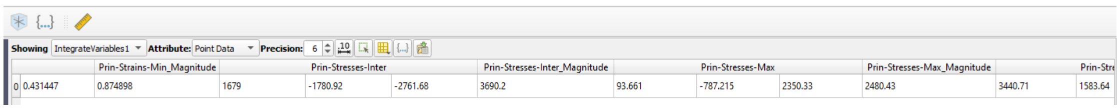
Temporal data analysis initiates by first selecting a point , and then point  the plot selection over time icon. You may select which variable to be plotted, Fig. 3.23.



(a) Cut slice

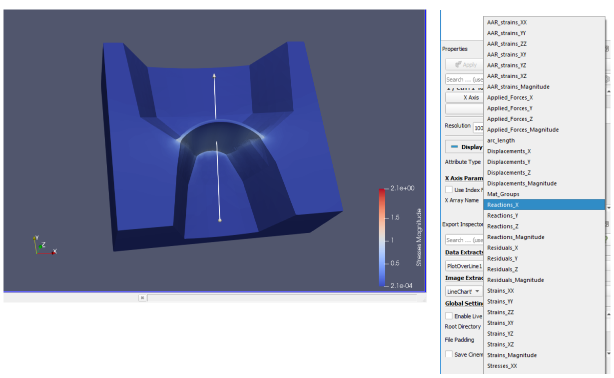


(b) Extract slice

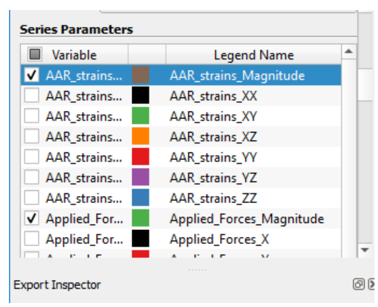


(c) Integration of all variables

Figure 3.21: Integration



(a) Select line of data points



(b) Series parameters

Figure 3.22: Plot data between two points

3.3.6 Split display

You can split the main window (as many times) and eeither display another view or a spreadsheet view, Fig. 3.24.

3.3.7 Spread-Sheet view

You can view any of the cell or point values on a table (that can be saved in `csv` formatted file, Fig. 3.25. Note that the point or cell selected in the table is also highlighted in the display.

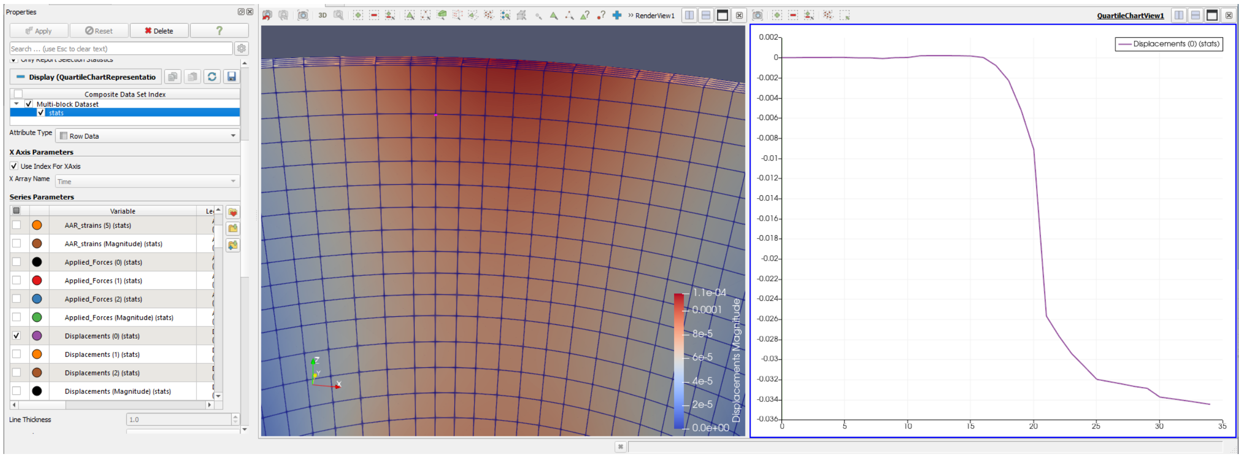


Figure 3.23: Temporal data analysis

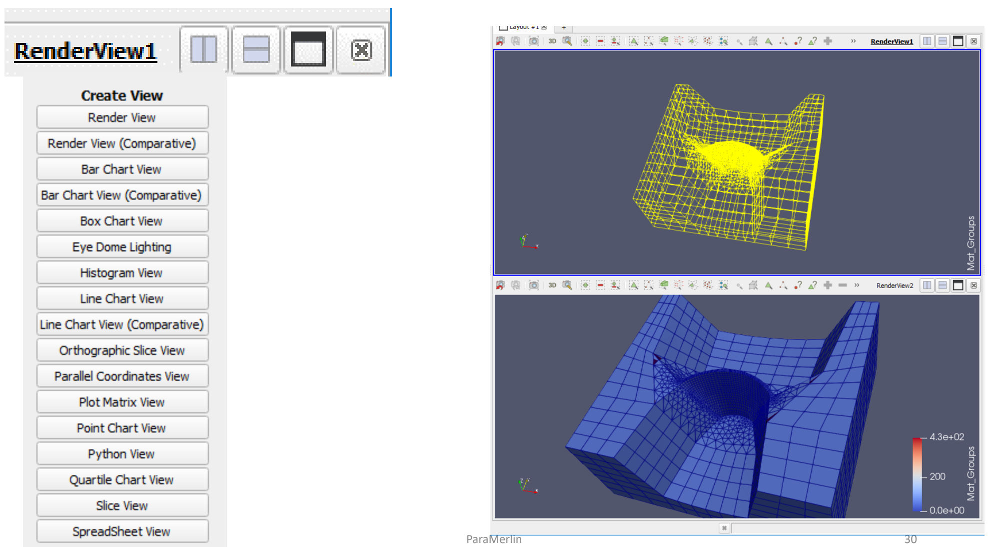


Figure 3.24: Split display

3.4 Brush Selection

The Brush selection provides numerous useful tools, Fig. 3.26. For the most part they are self-explanatory. Of particular importance are, Fig. 3.27

- Hover to display relevant point or cell data
- Select point or cells (lasso type) for extraction
- Interactively select (surface or through) points or cells

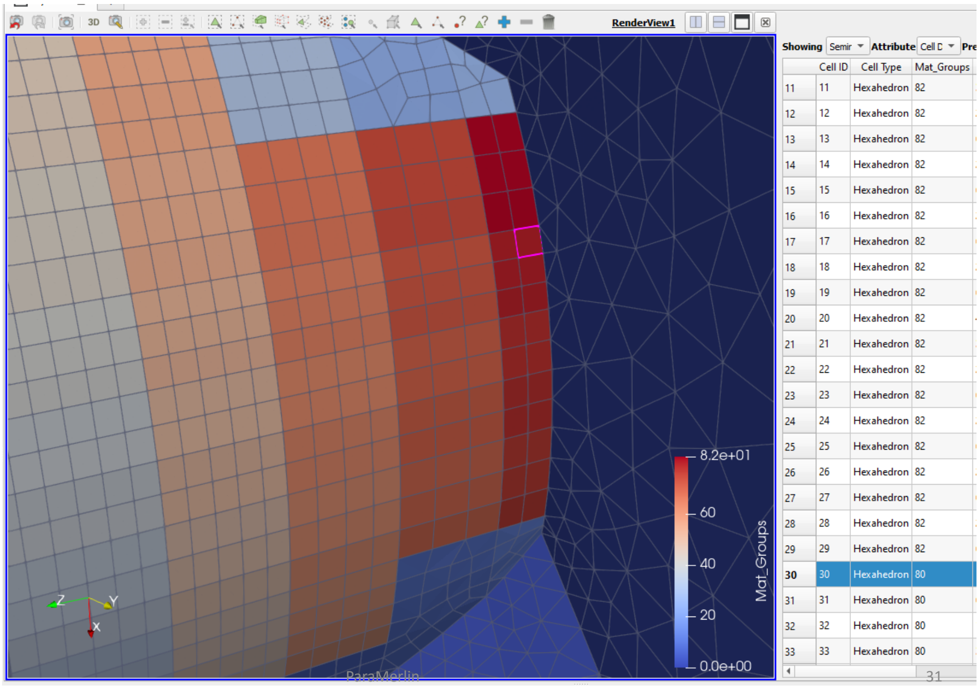


Figure 3.25: Spread-Sheet display

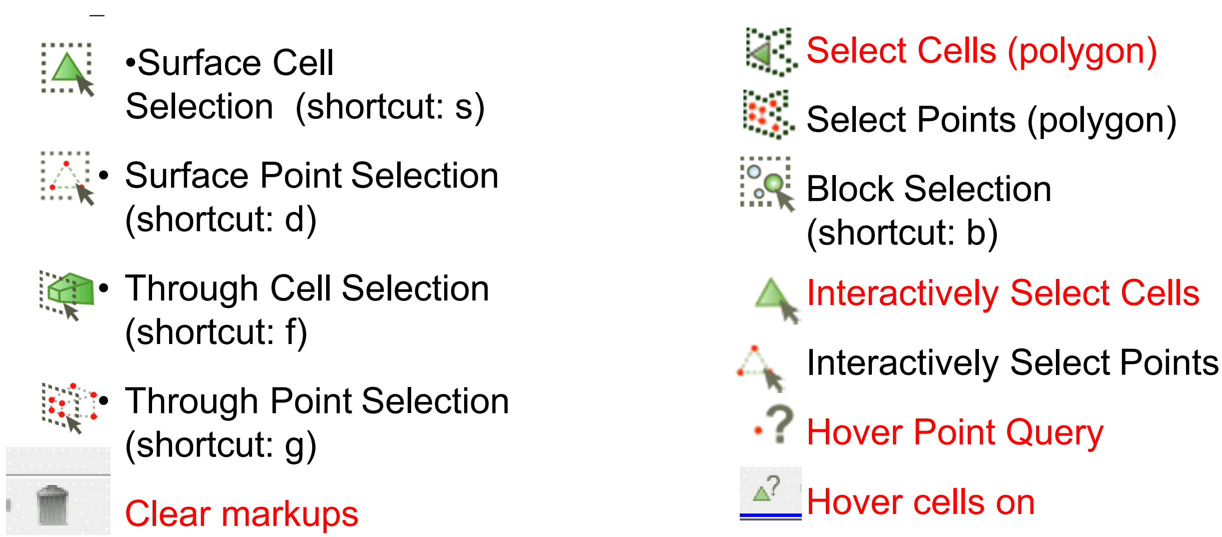


Figure 3.26: Brush Selection

3.5 Plot deformed shape

You can plot the deformed shape based on any vector (not necessarily displacements), Fig. 3.28. In Paraview jargon, this is called Wrap by a vector

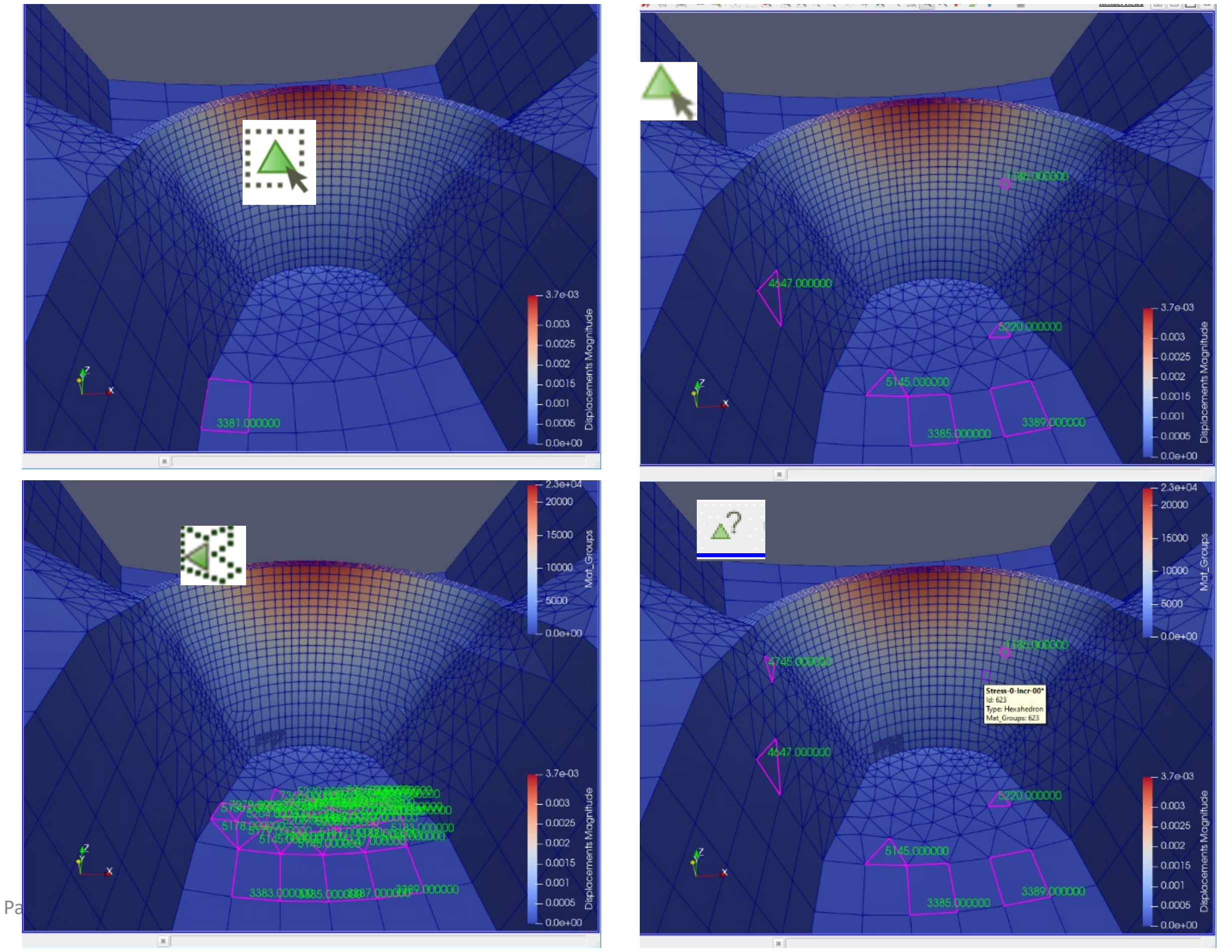


Figure 3.27: Examples of brush selections

3.5.1 Shrink Plot

A shrink plot can be obtained through the Shrink Filter by a factor shwon on the left, Fig. 3.29.

3.6 Smeared cracks

Whenever the `.pst` file contains data for smeared cracks, those can be displayed in any one of 3 forms. Note that `pst` file contains a single COD which is the average of those in the element integration points.

Oriented disks of non zero COD for each element, Fig. 3.30(a) and 3.30(b)

Element variable flat colored elements, Fig. 3.30(c)

Point variable Maximum value of surrounding a node is assigned to it, Fig. 3.30(d)

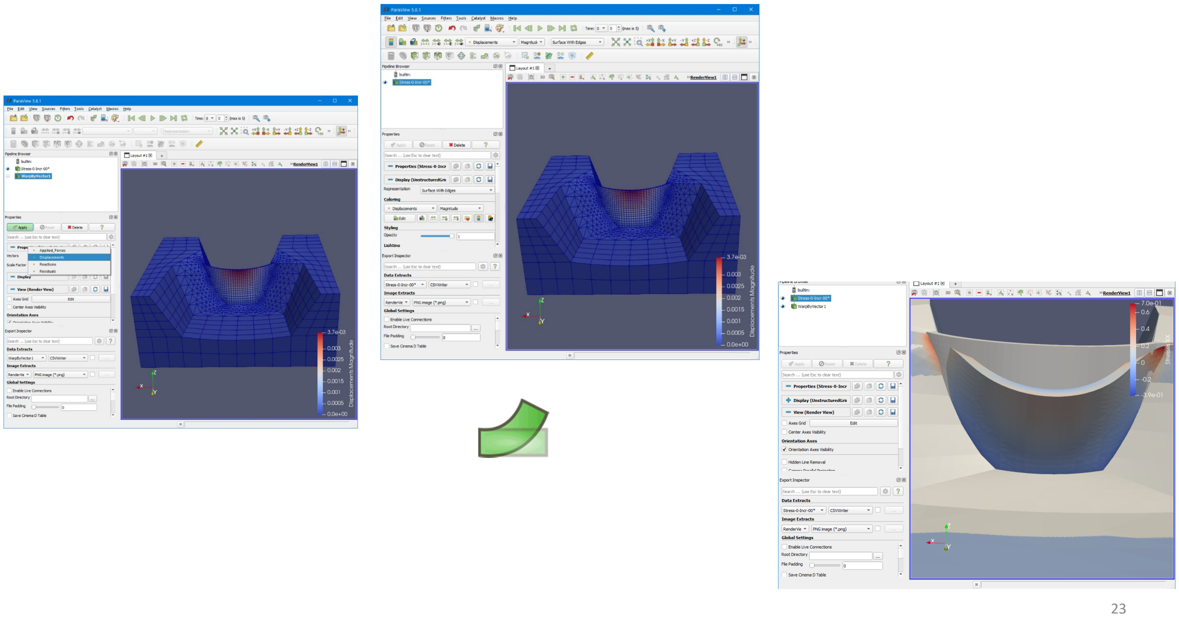


Figure 3.28: Example of deformed shape

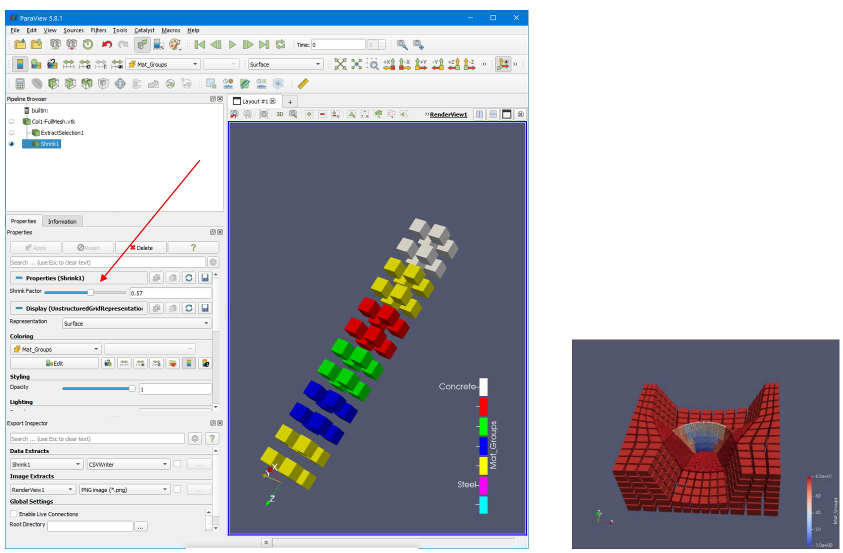
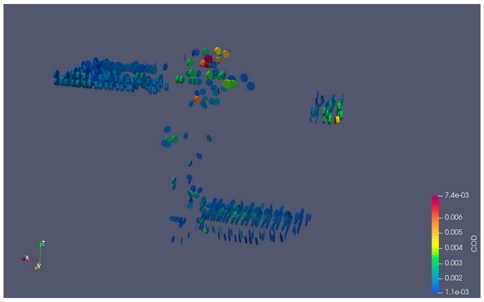


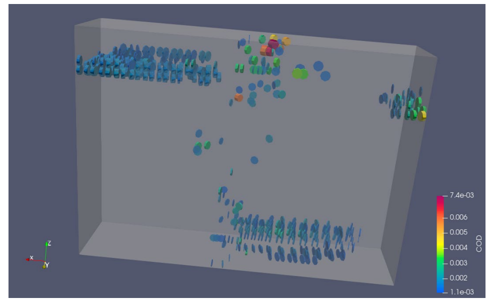
Figure 3.29: Shrink Plot

Histograms for each increment COD histogram is plotted and saved as a pdf, Fig. 3.30(e)

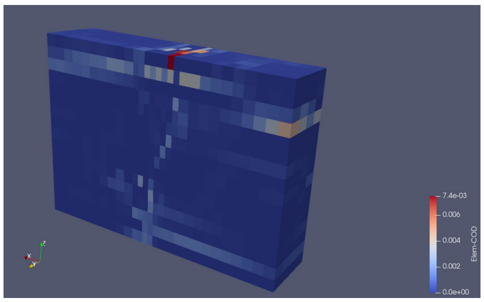
Excel file CODs for each crack are written on an Excel file, one sheet per increment, Fig. Fig. 3.30(f)



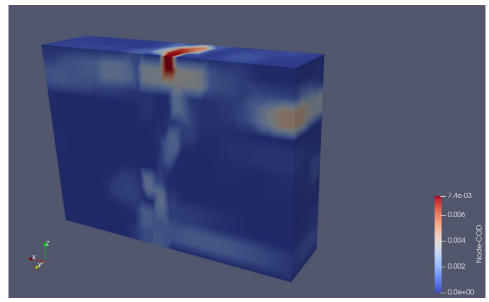
(a) Oriented disks



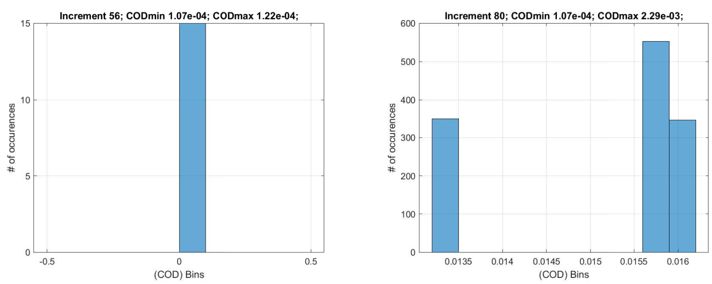
(b) Oriented disks within mesh



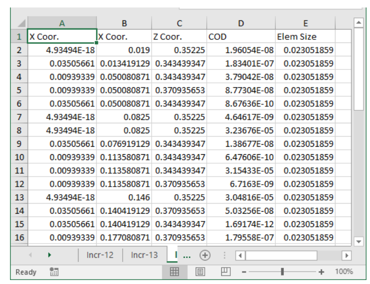
(c) Element based



(d) Node based



(e) Historgrams of COD for each increment



	A	B	C	D	E
1	X Coor.	X Coor.	Z Coor.	COD	Elem Size
2	4.93494E-18	0.019	0.35225	1.96054E-08	0.023051859
3	0.03505661	0.013419129	0.343439347	1.83401E-07	0.023051859
4	0.00939339	0.050080871	0.343439347	3.79042E-08	0.023051859
5	0.00939339	0.050080871	0.370935653	8.77304E-08	0.023051859
6	0.03505661	0.050080871	0.343439347	8.67636E-10	0.023051859
7	4.93494E-18	0.0825	0.35225	4.64617E-09	0.023051859
8	4.93494E-18	0.0825	0.35225	3.23676E-05	0.023051859
9	0.03505661	0.076919129	0.343439347	1.38677E-08	0.023051859
10	0.00939339	0.113580871	0.343439347	6.47606E-10	0.023051859
11	0.00939339	0.113580871	0.343439347	3.15433E-05	0.023051859
12	0.00939339	0.113580871	0.370935653	6.7163E-09	0.023051859
13	4.93494E-18	0.146	0.35225	3.04816E-05	0.023051859
14	0.03505661	0.140419129	0.370935653	5.03256E-08	0.023051859
15	0.03505661	0.140419129	0.343439347	1.69174E-12	0.023051859
16	0.00939339	0.177080871	0.370935653	1.79558E-07	0.023051859

Incr-12 Incr-13
Ready 100%

(f) Excel tabulation

Figure 3.30: Possible displays of smeared cracks

3.7 Animation

3.7.1 Time step bar

Time step progrss bar can be visualized through the corresponding filter, Fig. 3.31.

3.7.2 Save animation

Animation can be saved, Fig. 3.32.

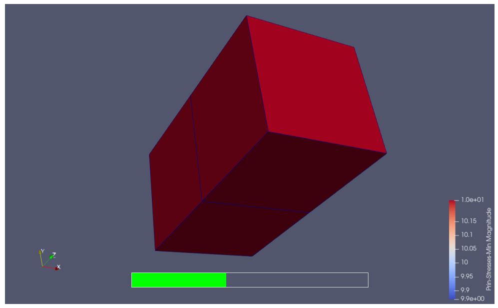


Figure 3.31: Time step bar

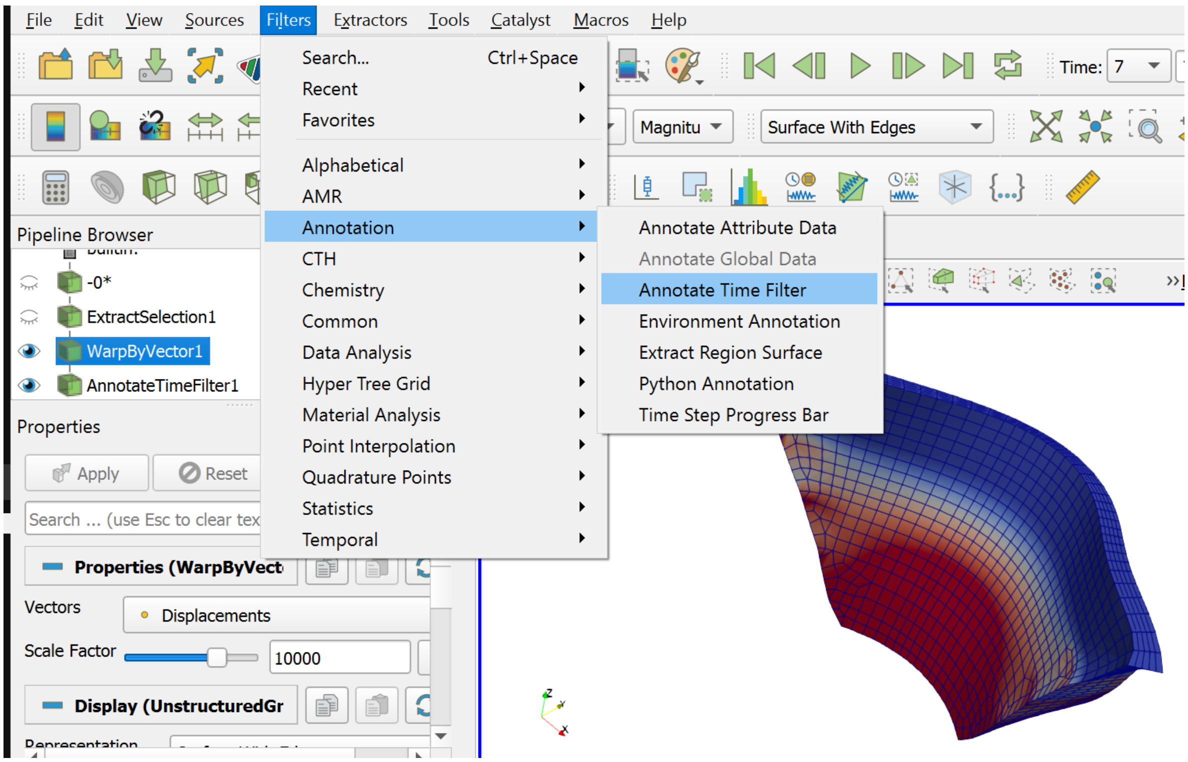


Figure 3.32: Save animation

3.7.3 Saving display

Saving the display, Fig. 3.33

File-¿Export Scene-¿ file format (such as eps, svg, bmp, jpg, or tiff)

Note that you can also click on the camera icon (third right above the display) and capture the screenshot

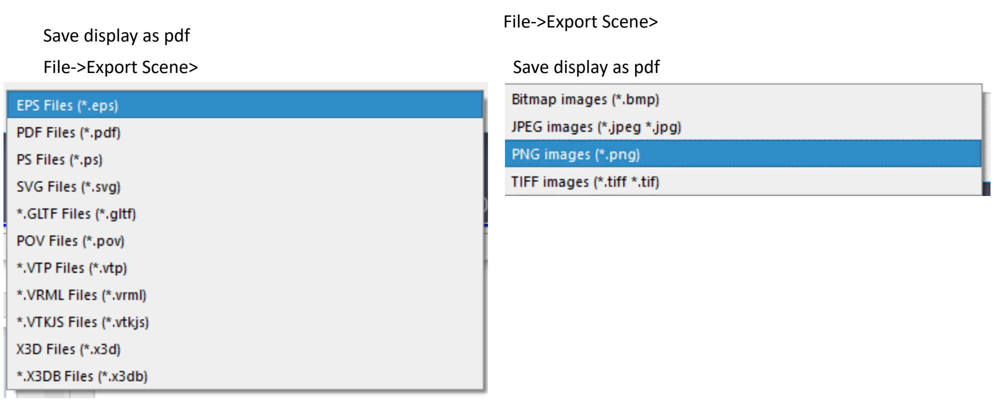


Figure 3.33: Display scene

Bibliography

Haussman, G. and V.E. Saouma (2009). *Spider, a 3D Interactive Graphics Finite Element Post-Processor; User's Manual*. URL: \url{http://civil.colorado.edu/~saouma/pdf/spider.pdf}.

Saouma, V.E., J. Červenka, and R.W. Reich (2010). *Merlin Finite Element User's Manual*.