User Guide

Matlab Load Path Plotting Algorithm

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Plotting Load Paths for mesh and stress files using the Hex8 3D finite element

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This User Guide describes features of the MatLab program prepared for release at the AIAA SciCom 2019 Conference, San Diego 7-11 January 2019 [1]. The program reads mesh data and stresses from text files created by a finite element solution that is run independently by the user. It then defines the vector field and plots the load paths using the Runge-Kutta algorithm described in the paper.

The MatLab application can be downloaded from the GitHub website

https://github/GarthPearce/LoadPathMATLAB

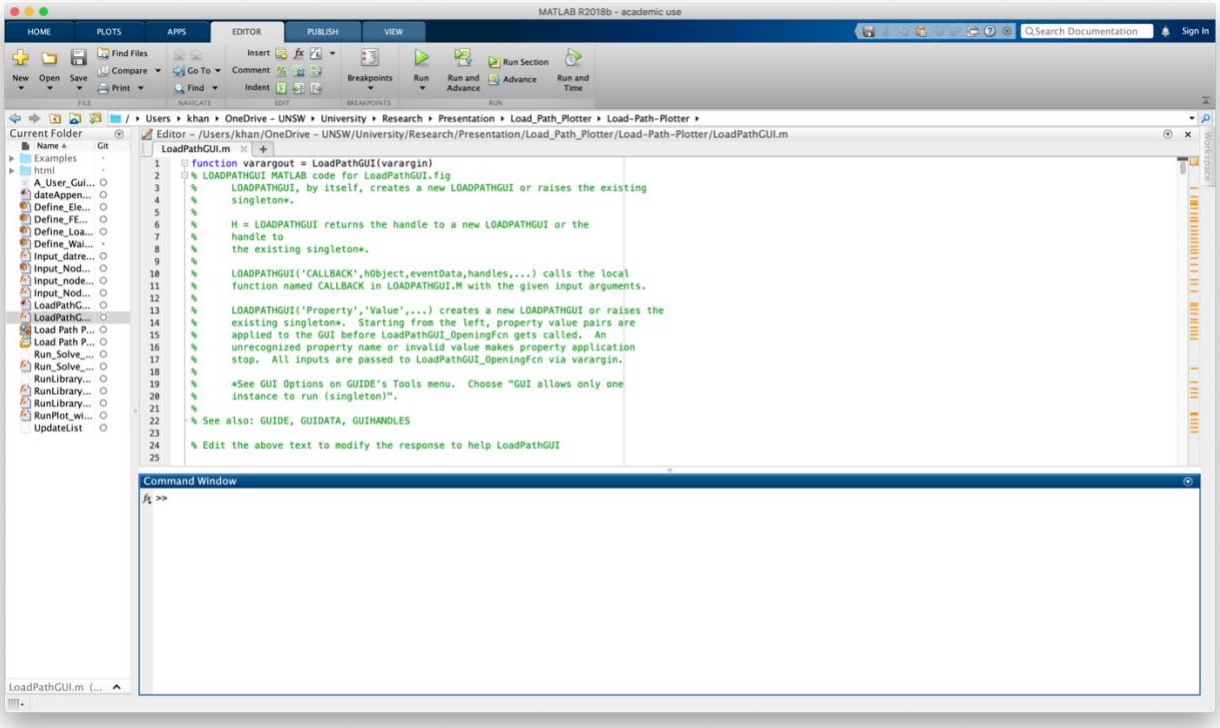
The site contains the source of the program, and a number of example sets of data.

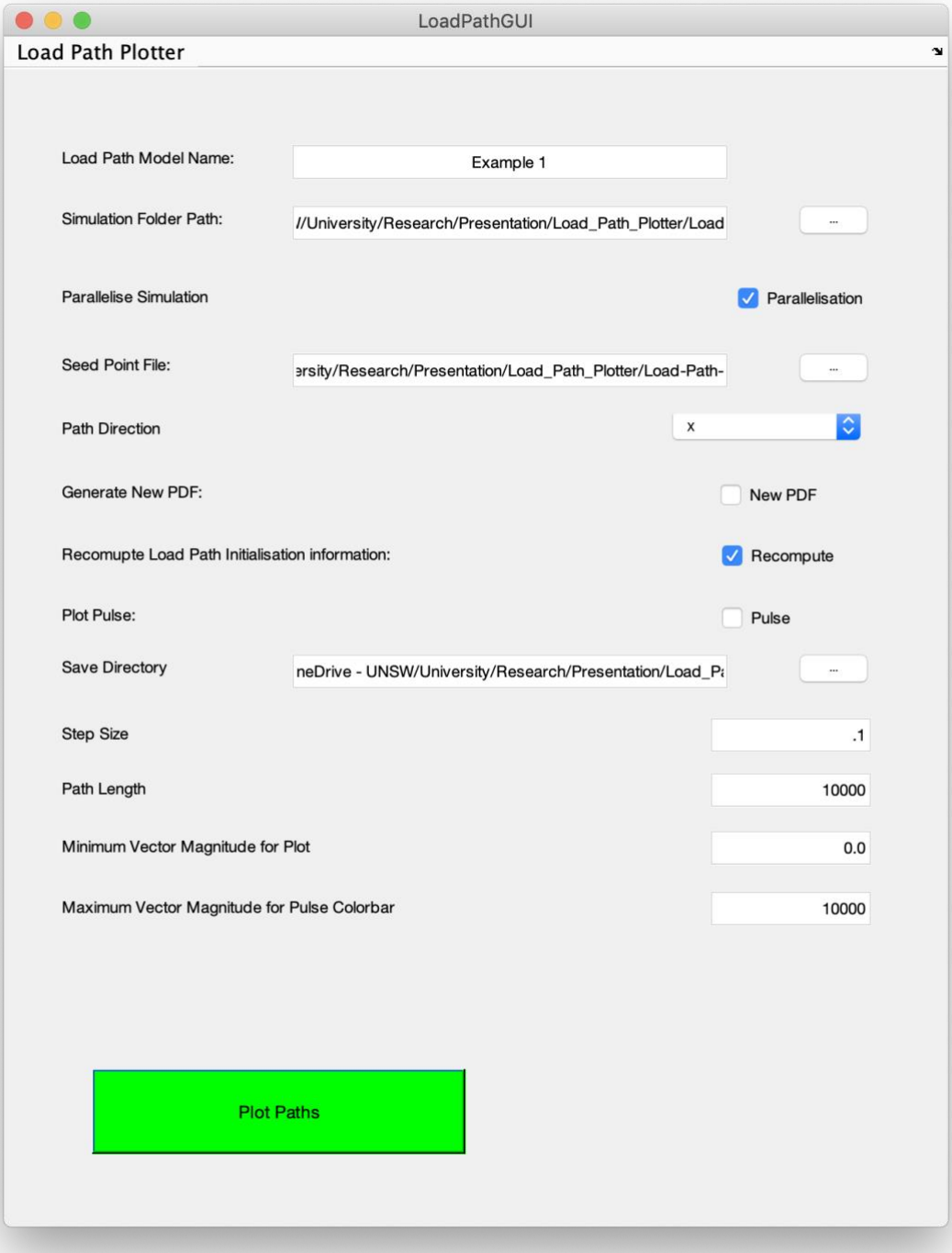
Contents

Installation

Download the files in the director “Load-Path-Plotters” to your chosen MatLab run directory.

To launch the program navigate to your chosen directory and select the LoadPathGui.m file and press “Run”. The graphical user interface show below will appear.




LoadPathGUI
Load Path Plotter
Load Path Model Name:
Example 1
Simulation Folder Path:
//University/Research/Presentation/Load_Path_Plotter/Load
...
Parallelise Simulation
Parallelisation
Seed Point File:
ersity/Research/Presentation/Load_Path_Plotter/Load-Path-
...
Path Direction
x
Generate New PDF:
New PDF
Recomupte Load Path Initialisation information:
Recompute
Plot Pulse:
Pulse
Save Directory
neDrive - UNSW/University/Research/Presentation/Load_Pa
...
Step Size
.1
Path Length
10000
Minimum Vector Magnitude for Plot
0.0
Maximum Vector Magnitude for Pulse Colorbar
10000
Plot Paths

Example Run

To run the first data set in the Examples Directory.

Simulation Folder Path
<MatLab run directory>\Examples\Example 1 Isotropic Plate With Loaded Hole\Simulation Files

Parallelisation tab – No

Dimension of Simulation – 3D (current version only works in 3D)

Seed Point File
<MatLab run directory>\Examples\Example 1 Isotropic Plate With Loaded Hole\Y-Seeds (Primary)

Path Direction – Y

New pdf – Yes

Recompute – Yes

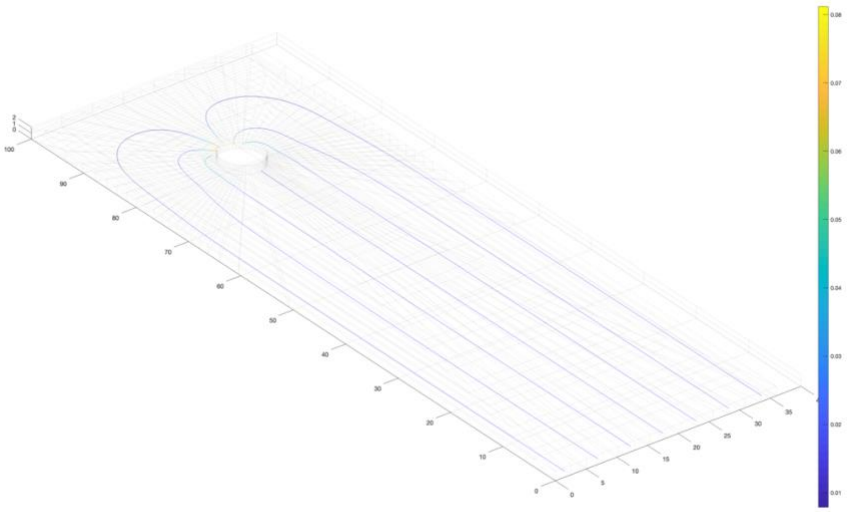
Save Directory - <MatLab run directory>\Examples\Example 1 Isotropic Plate With Loaded Hole

Step Size – 1

Path Length – 100

Minimum Vector Magnitude for Plot – 0.0

Plot Paths … following image will be created



Program Features

1. The application only works for finite element mesh and stress files created using Hex8 elements (8-noded 3d bricks)
2. The program reads node coordinates and element connectivity from a file (ds.dat) written to a fixed format.
3. The program reads node stresses from a file (nodalSolution.txt) written to a fixed format.
4. The contours are generated by a Runge-Kutta algorithm (see Reference [1]).
5. Commencing points for the contours are defined
    a. In a file xxxx.dat identified in the GUI created when the program is run.
    b. If the file is empty the Seeds are generated by the program. A seed is located at the centroid of element with the maximum magnitude of the Load Path Vector selected for the plot. Seeds are created on other elements with the same coordinate (in the Load Path Vector direction) to form a rake. This method facilitates the plot of the pulse.
6. The program ensures the normal vectors for all element faces on the HEX8 elements point outwards
    a. Define centroid of element and store in an array
    b. Define centroid of face and vector V1 from centroid of element to centroid of face
    c. Define normal to face Vn as vector cross-product of two edges (store in array)
    d. If vector dot product V1.Vn is positive – ok
    e. If vector dot product V1.Vn is negative – reorder nodes on face and reverse direction of Vn.
7. A simple code is used to determine which element point p0 is inside – may not work for highly distorted meshes.
    a. Loop over all elements
    b. Loop over all faces of the element
    c. Form vector V2 from centroid of the face to p0.
    d. Calculate the vector dot product of V2 and outward face normal.
    e. If all dot products are negative or zero p0 is in that element or on the surface of the element.
    f. If vector dot product is positive for any one face, p0 is outside element.
8. For plot of transient propagation of pulse – see blocks of code ‘if pulse == 1’ in loadpath3D.m
    a. Plot only peak of pulse – In GUI set minimum below which path will not be plotted.
    b. In GUI set maximum for colorbar from review of finite element. Same maximum to be used across all time steps so plot will show change in maximum.
9. To create movie
    a. Create a set of result files at different time steps
    b. Run load path program for each result file and store image as bmp file
    c. Run separate Movie.m program to create avi file.

Format of Input Files

Two files are required in addition to the data provided in the GUI. The format for these files defaults to ANSYS format. For other FEA packages the files might need to be edited

ds.dat

First 3 lines give a title comment, block information (3D and number of nodes) and read format

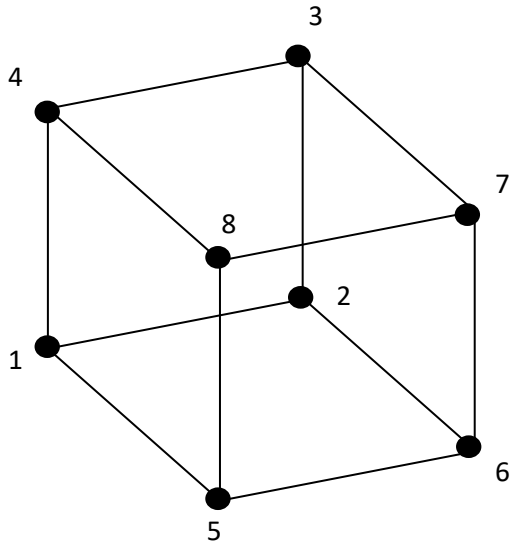
Followed by list of node coordinates.

The list ends with "-1"

Title line for Elements, Element type (use et,1,185), block data including number of entries on line and number of elements and line giving format for read.

Followed by list of element node connectivity. Last 9 entries on each line give element number and node connectivity. Only 8-node brick elements are supported for this release. The node numbers need to be sequential (clockwise or anticlockwise) for a back face – then numbered on the front face in the same sequence – see figure below.

The list ends with "-1"



The data for the "ds.dat" should be formatted as follows:
For Nodes:

```
/com,*********** Nodes for the whole assembly ***********
nblock,3,,2040
(1i9,3e20.9e3)
        1    4.691736454E-001    9.265370399E+001    0.000000000E+000
        2    1.234722982E+000    9.191286156E+001    0.000000000E+000
        3    2.433251521E+000    9.116130772E+001    0.000000000E+000
        4    3.631780060E+000    9.040975387E+001    0.000000000E+000
        5    4.830308599E+000    8.965820003E+001    0.000000000E+000
        6    6.028837138E+000    8.890664618E+001    0.000000000E+000
        7    7.227365677E+000    8.815509234E+001    0.000000000E+000
        8    8.425894216E+000    8.740353849E+001    0.000000000E+000
        9    9.624422755E+000    8.665198465E+001    0.000000000E+000
       10    1.082295129E+001    8.590043080E+001    0.000000000E+000
       11    1.202147983E+001    8.514887696E+001    0.000000000E+000
       12    1.322000837E+001    8.439732311E+001    0.000000000E+000
       13    1.438365197E+001    8.365116263E+001    0.000000000E+000
       14    1.091830669E+000    8.960184381E+001    0.000000000E+000
       15    2.183661337E+000    8.906479500E+001    0.000000000E+000
```

For Elements:

```
/com,********** Elements for Body 1 "IsoBoltHoleNoSplit" **********
et,1,185
eblock,19,solid,,952
(19i9)
        1        1        1        1        0        0        0        0        8        0        1      871      884     1993     1994      898      885     1835     1836
        1        1        1        1        0        0        0        0        8        0        2      858      871     1994     1995      911      898     1836     1834
        1        1        1        1        0        0        0        0        8        0        3      845      858     1995     1996      924      911     1834     1833
        1        1        1        1        0        0        0        0        8        0        4      832      845     1996     1997      937      924     1833     1832
        1        1        1        1        0        0        0        0        8        0        5      819      832     1997     1998      950      937     1832     1831
        1        1        1        1        0        0        0        0        8        0        6      806      819     1998     1999      963      950     1831     1830
        1        1        1        1        0        0        0        0        8        0        7      793      806     1999     2000      976      963     1830     1829
        1        1        1        1        0        0        0        0        8        0        8      780      793     2000     2001      989      976     1829     1828
        1        1        1        1        0        0        0        0        8        0        9      767      780     2001     2002     1002      989     1828     1827
        1        1        1        1        0        0        0        0        8        0       10      754      767     2002     2003     1015     1002     1827     1826
        1        1        1        1        0        0        0        0        8        0       11      741      754     2003     2004     1028     1015     1826     1825
        1        1        1        1        0        0        0        0        8        0       12      728      741     2004     2005     1041     1028     1825     1824
        1        1        1        1        0        0        0        0        8        0       13      715      728     2005     2006     1054     1041     1824     1823
        1        1        1        1        0        0        0        0        8        0       14      702      715     2006     2007     1067     1054     1823     1822
        1        1        1        1        0        0        0        0        8        0       15      689      702     2007     2008     1080     1067     1822     1821
        1        1        1        1        0        0        0        0        8        0       16      676      689     2008     2009     1093     1080     1821     1820
        1        1        1        1        0        0        0        0        8        0       17      663      676     2009     2010     1106     1093     1820     1819
        1        1        1        1        0        0        0        0        8        0       18      650      663     2010     2011     1119     1106     1819     1818
```

nodalSolution.txt

File containing stresses at nodes in global coordinates.
Title line followed by one line for each node giving node number followed by 6 stress values.

The "nodalSolution.txt" file be in the following format:

NODE	SX	SY	SZ	SXY	SYZ	SXZ
1	-0.36352E-002	0.42950E-002	0.36216E-003	0.45382E-003	-0.24736E-003	-0.12258E-003
2	-0.33716E-002	0.45819E-002	0.23067E-003	0.11115E-002	-0.36570E-004	-0.19699E-004
3	-0.30108E-002	0.51225E-002	0.25618E-003	0.20503E-002	-0.82953E-004	-0.52202E-004
4	-0.27901E-002	0.58388E-002	0.21418E-003	0.30664E-002	-0.18486E-003	-0.88777E-004
5	-0.27805E-002	0.66020E-002	0.17911E-003	0.41374E-002	-0.21426E-003	-0.95476E-004
6	-0.29615E-002	0.73715E-002	0.16815E-003	0.52435E-002	-0.19316E-003	-0.94054E-004
7	-0.33366E-002	0.81569E-002	0.16452E-003	0.64208E-002	-0.15486E-003	-0.96404E-004
8	-0.39594E-002	0.89839E-002	0.16649E-003	0.77862E-002	-0.12108E-003	-0.10691E-003
9	-0.49442E-002	0.99005E-002	0.18640E-003	0.95391E-002	-0.98337E-004	-0.12279E-003
10	-0.65050E-002	0.10933E-001	0.16377E-003	0.12053E-001	-0.82650E-004	-0.15774E-003

nodeInfo.txt

Two lines giving number of nodes for stress file read.

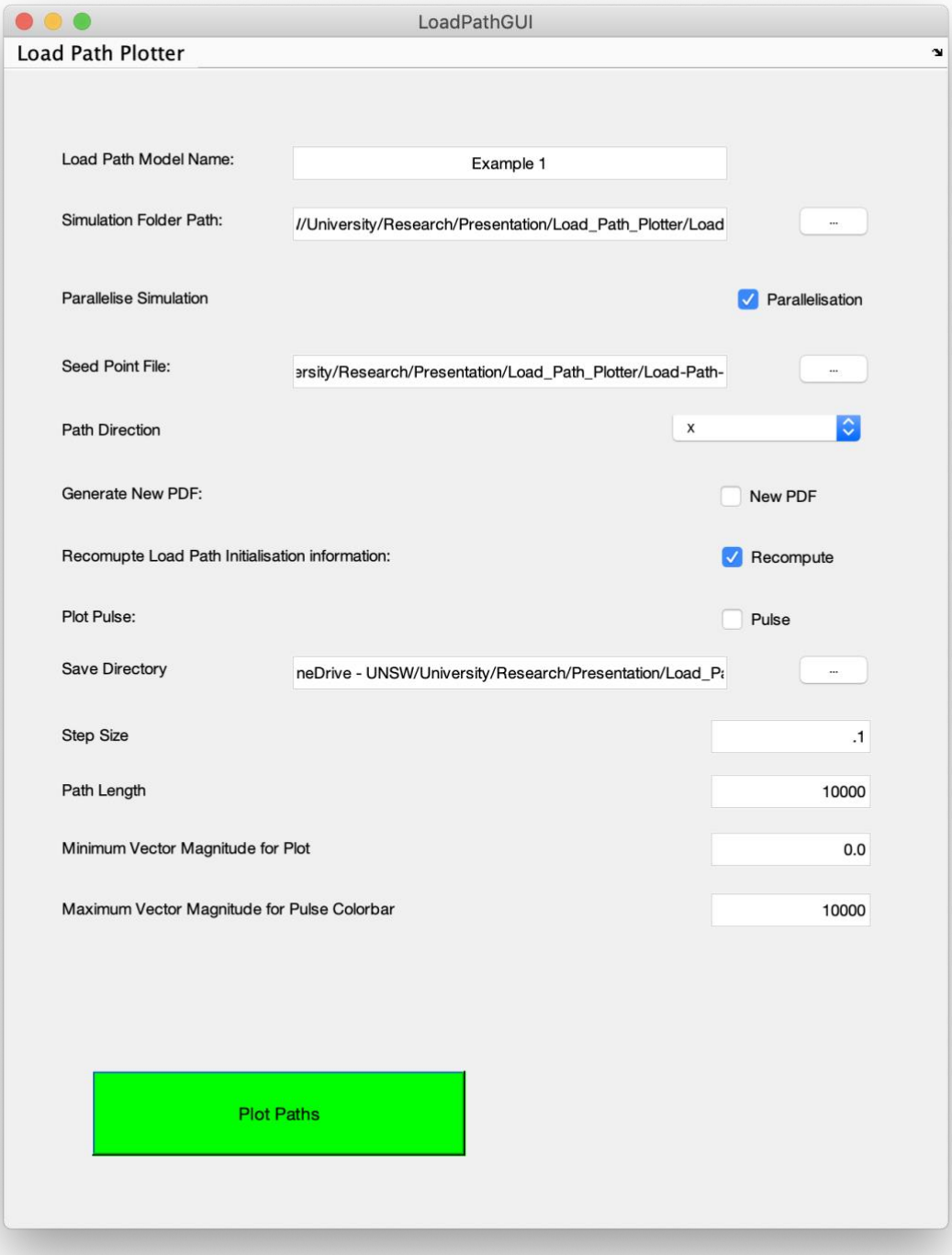
The "nodalInfo.txt" file be in the following format:

```
1    1.0000000E+00
2    2.0400000E+03
```

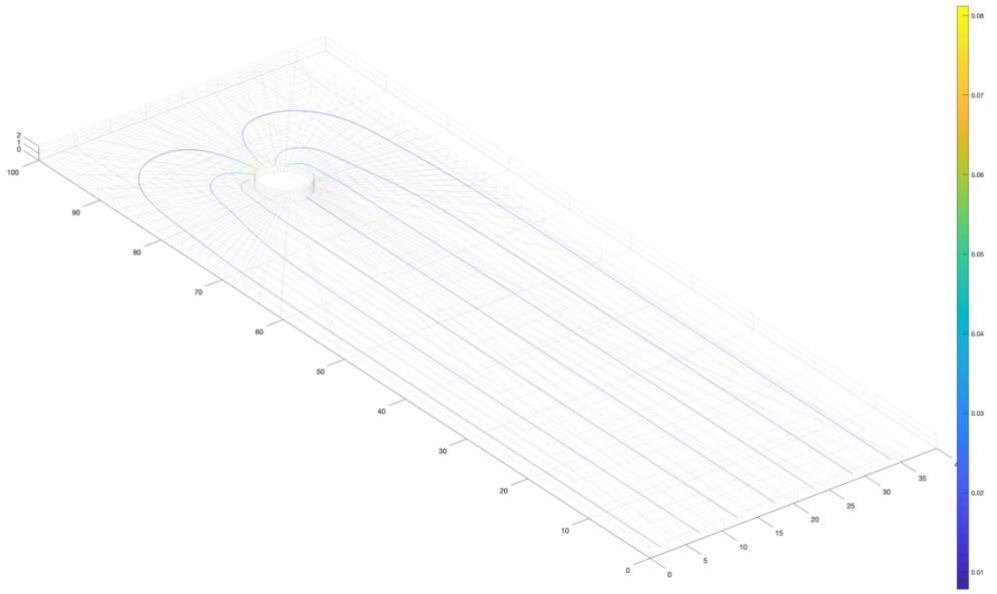
References

[1] D. Kelly, G. Pearce and K. Schroder-Turner. "Plotting Load Paths from Finite Element Stress Results for Aerospace Structures" Proceedings SciTech 2019, January 7-11, San Diego 2019.

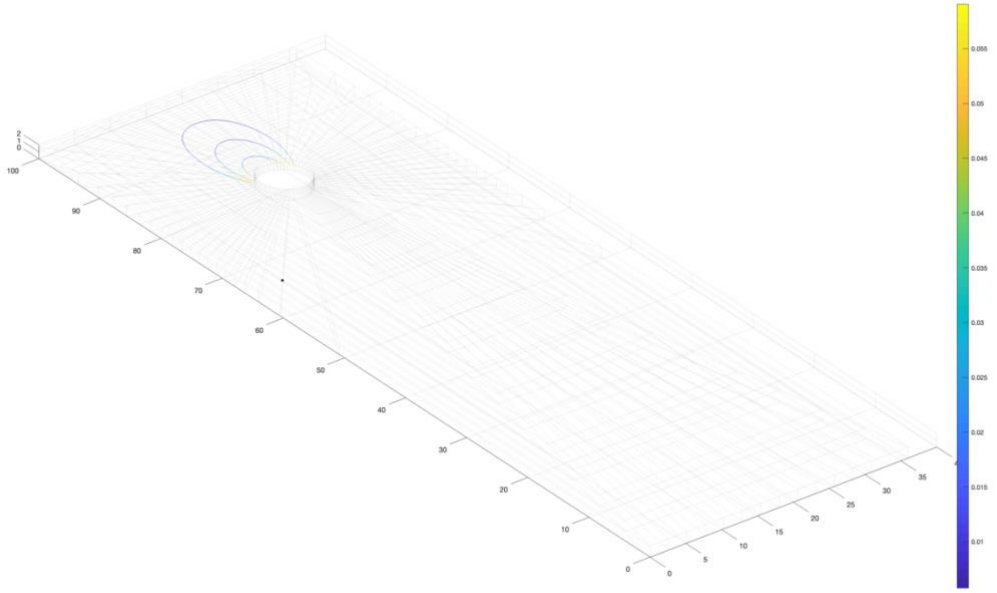
Example 1 – Pin Loaded Hole



Y-direction load paths

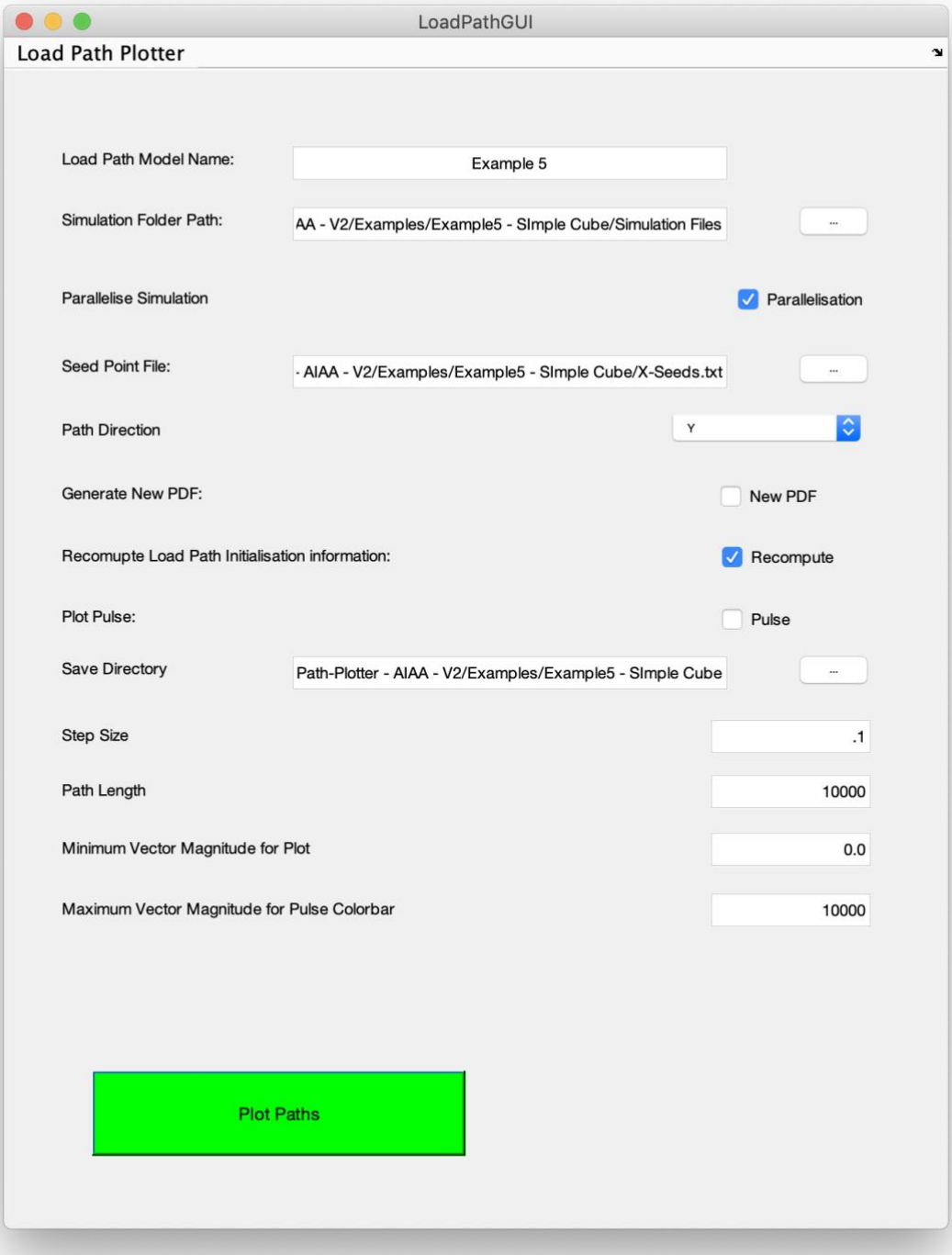


X-direction load paths

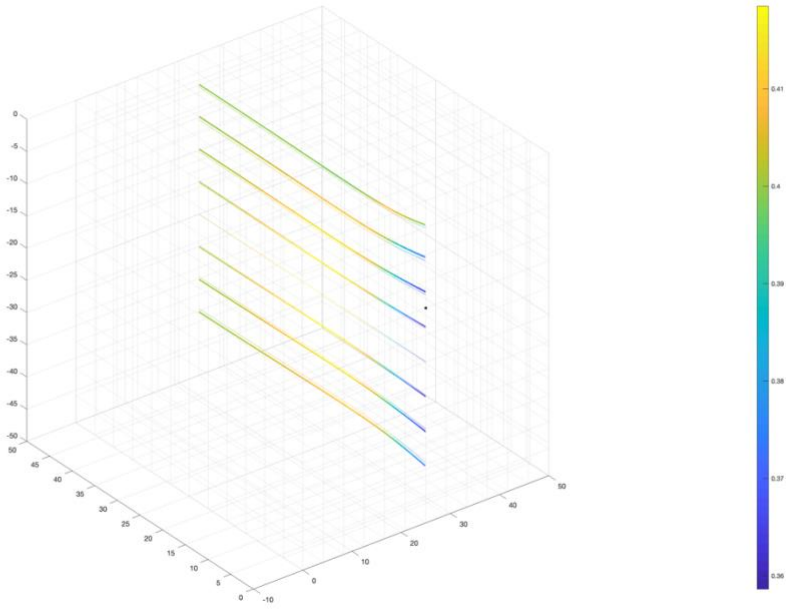


Example 5 – Simple Cube

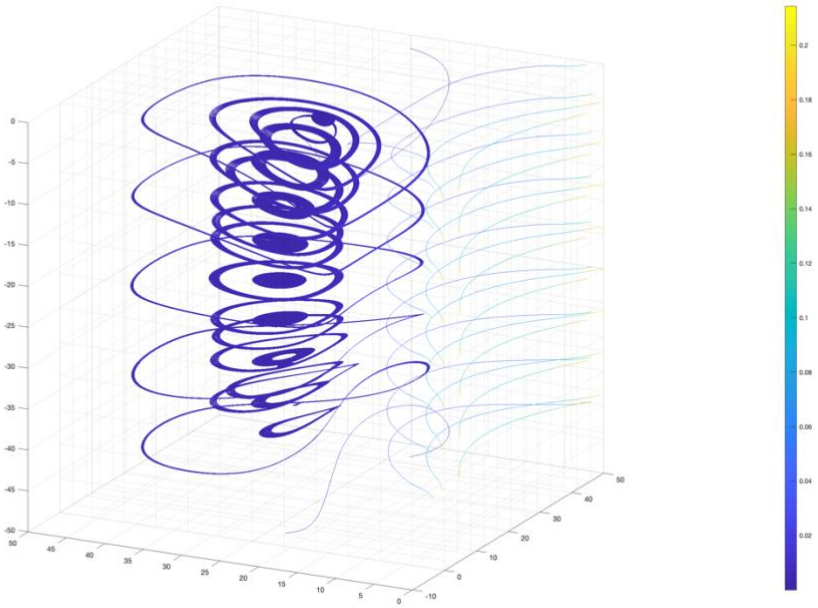
Example 5 can be produced with the following settings:



This will yield the following plot:

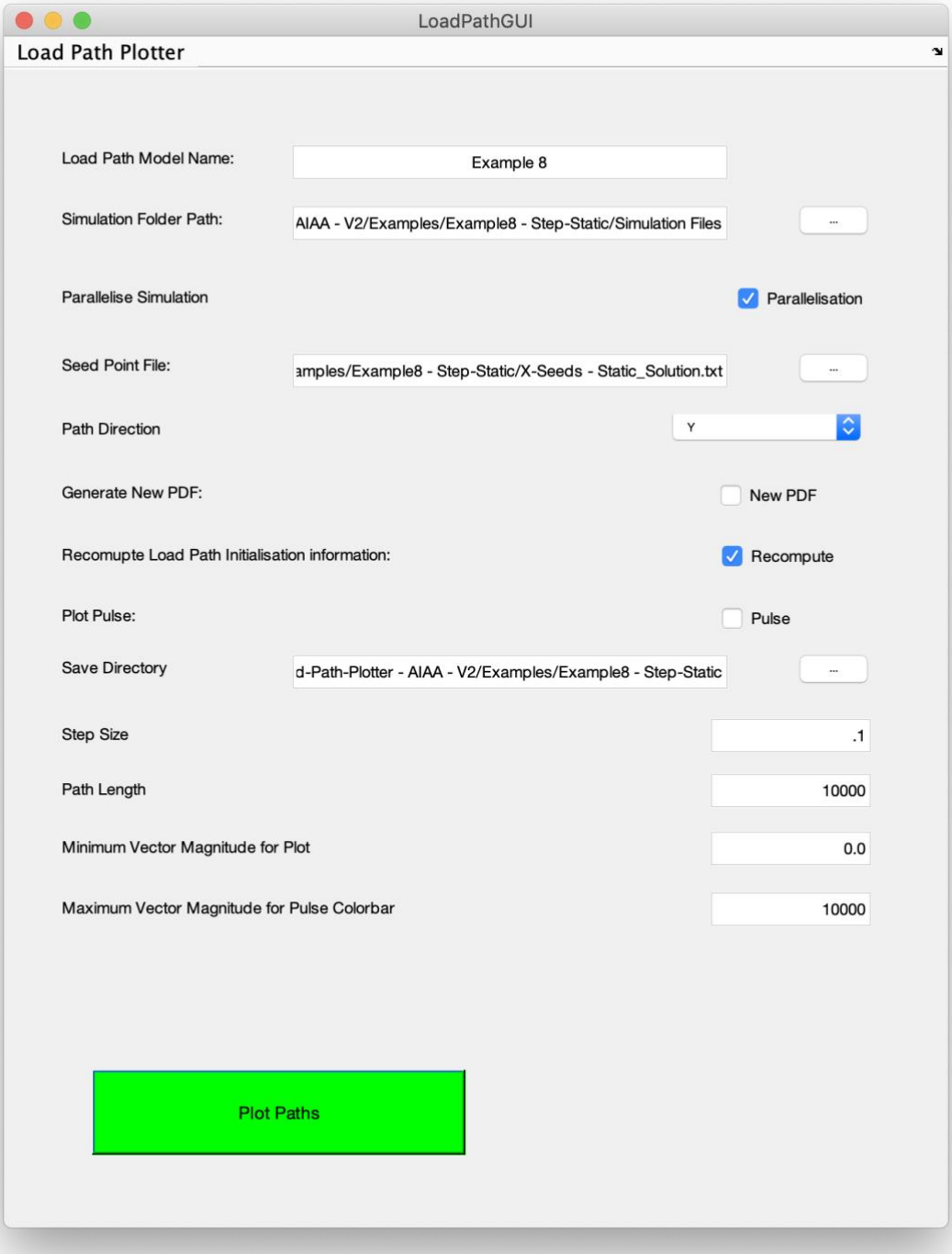


Changing the path direction from "Y" to "X" file will yield (the values in dark blue are very near zeros, hence this can be assumed to be a round off error):

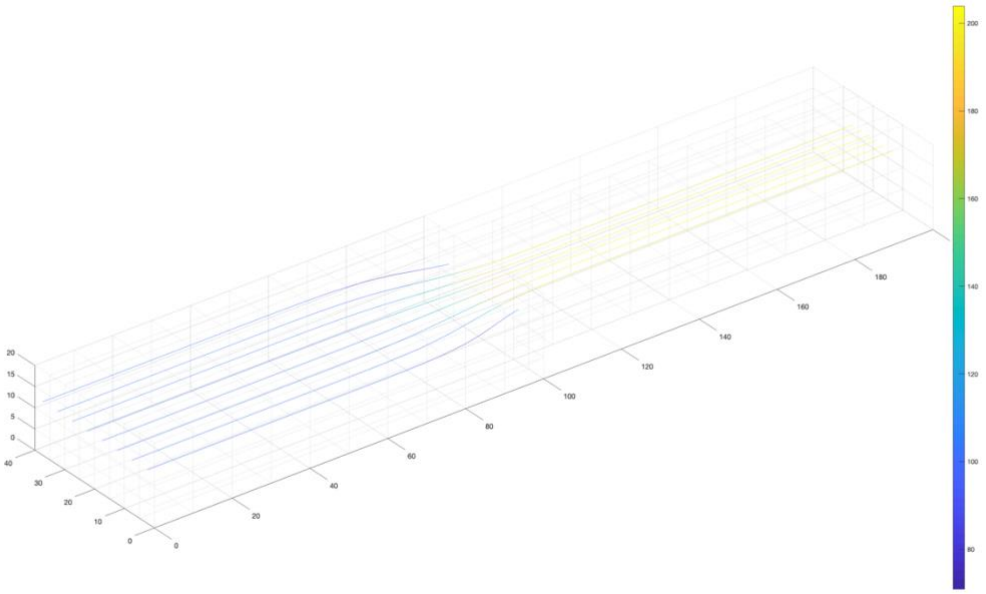


Example 8 – Step - Static Solution

Example 8 can be produced with the following settings:



This will yield the following plot:


20
15
10
5
0
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
180
160
140
120
100
80