FC-GRAPHICS4MESH Matlab toolbox, User's Guide [*]under rhum-ubuntu-16-04-3lts computer

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Abstract

This Matlab toolbox allows to display simplicial meshes or datas on simplicial meshes. A simplicial mesh must be given by two arrays : the vertices array and the connectivity array.

0 Contents

[*]Compiled with Matlab 2017a

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1 Introduction

The **experimental** Matlab toolbox uses internal functions for displaying simplicial meshes or datas on simplicial meshes. Simplicial meshes could be:

- a triangular mesh in dimension 2, made with 2-simplices (ie. triangles),
- a tetrahedral mesh in dimension 3, made with 3-simplices (ie. tetrahedron),
- a triangular mesh in dimension 3 (surface mesh), made with 2-simplices,
- a line mesh in dimension 2 or 3 made with 1-simplices (ie. lines).

A simplicial mesh is given by its vertices array q and its connectivity array me. For demonstration purpose, some simplicial meshes are given in this package. They can be load by using the function getMesh2D, getMesh3D or getMesh3Ds of the fc_graphics4mesh package.

This toolbox was tested under

Windows 10: with Matlab R2015b to R2017b (opengl hardware mode with NVIDIA driver 376.84 on a Quadro K600)

MacOS Sierra: with Matlab R2015b to R2017b (opengl hardware mode with Intel driver 10.2.37 on a HD 3000)

Ubuntu 14.04.5 LTS: with Matlab R2017a, R2016b

Ubuntu 16.04 LTS: with Matlab R2015b, R2017b (opengl hardware mode), R2016a to R2017a (opengl software mode)

2 Installation

2.1 Installation automatic, all in one (recommanded)

For this method, one just have to get/download the install file

mfc_graphics4mesh_install.m

or get it on the dedicated web page. Thereafter, one run it under Matlab. This command download, extract and configure the *fc-graphics4mesh* and the required *fc-tools* toolbox in the current directory.

For example, to install this toolbox in `~/Matlab/toolboxes` directory, one have to copy the file mfc_graphics4mesh_install.m in the `~/Matlab/toolboxes` directory. Then in a Matlab terminal run the following commands

```
>> cd ~/Matlab/toolboxes
>> mfc_graphics4mesh_install
```

There is the output of the `mfc_graphics4mesh_install` command on a Linux computer:

```
1- Downloading and extracting the toolboxes
   -> <fc-tools>[0.0.19] ... OK
   -> <fc-graphics4mesh>[0.0.2] ... OK
2- Setting the <fc-graphics4mesh> toolbox
Write in ...
    ~/Matlab/toolboxes/fc-graphics4mesh-full/fc_graphics4mesh-0.0.2/configure_loc.m ...
    ...
  -> done
3- Using the <fc-graphics4mesh> toolbox
   Under Matlab:
     addpath('~/Matlab/toolboxes/fc-graphics4mesh-full/fc_graphics4mesh-0.0.2')
     fc_graphics4mesh.init()

   See ~/Matlab/toolboxes/mfc_graphics4mesh_set.m
```

The complete toolbox (i.e. with all the other needed toolboxes) is stored in the directory `~/Matlab/toolboxes/fc-graphics4mesh-full` and, for each Matlab session, one have to set the toolbox by:

```
>> ...
    addpath('~/Matlab/toolboxes/fc-graphics4mesh-full/mfc-graphics4mesh-0.0.2')
>> fc_graphics4mesh.init()
```

For **uninstalling**, one just have to delete directory

`~/Matlab/toolboxes/fc-graphics4mesh-full`

2.2 Manual installation

This package uses the `fc_tools` toolbox. So one has to install it as explain in the dedicated web page.

Thereafter, on the `fc_graphics4mesh` dedicated web page, one can found link to archives (*zip*, *7z* or *tar.gz* format)

- Downloads an archive and extract it on a folder, for example `~/Matlab/toolboxes`. The toolbox path is `~/Matlab/toolboxes/mfc-graphics4mesh-0.0.2`
- Adds the toolbox path in Matlab with `addpath` command.
- Verifies that the the `fc_tools` toolbox is in the Matlab path. Otherwise, adds it...

3 Mesh

The functions getMesh2D, getMesh3D and getMesh3Ds return a mesh vertices array q, a mesh elements connectivity array associated with the input argument d (simplex dimension) and the indices array toGlobal. The vertices array q is a dim-by-$\mathrm{n_q}$ array where dim is the space dimension (2 or 3) and $\mathrm{n_q}$ the number of vertices. The connectivity array me is a $(d+1)$-by-$\mathrm{n_{me}}$ array where $\mathrm{n_{me}}$ is the number of mesh elements and $0 \leqslant d \leqslant dim$ is the simplicial dimension:

- $d = 0$: points,
- $d = 1$: lines,
- $d = 2$: triangle,
- $d = 3$: tetrahedron.

So we can use theses functions to obtain

- 3D mesh: getMesh3D(3) (*main* mesh), getMesh3D(2), getMesh3D(1), getMesh3D(0),
- 3D surface mesh: getMesh3Ds(2) (*main* mesh), getMesh3Ds(1) , getMesh3Ds(0),
- 2D mesh: getMesh2D(2) (*main* mesh), getMesh2D(1), getMesh2D(0).

For example,

- [q3,me3,toGlobal3]=fc_graphics4mesh.getMesh3D(3) return a 3-simplicial mesh (main mesh) in space dimension $dim = 3$,
- [q2,me2,toGlobal2]=fc_graphics4mesh.getMesh3D(2) return a 2-simplicial mesh in space dimension $dim = 3$.

The third output are indices of the vertices in the *main* mesh:
q3 (:, toGlobal2) == q2

4 PLOTMESH function

The function PLOTMESH displays a mesh given by

Syntaxe

```
fc_graphics4mesh.plotmesh(q,me)
fc_graphics4mesh.plotmesh(q,me,Name,Value, ...)
```

Description

plotmesh(q,me) displays all the Th.d-dimensional simplices elements.

plotmesh(q,me,Name,Value, ...) specifies function options using one or more Name,Value pair arguments. Options of first level are

- `'color'` : to specify the color of the displayed mesh elements. (default : 'blue'),
- `'cutPlan'` : (only for simplices in dimension 3) cut mesh by n plans given by n-by-4 array P where the equation of the i-th cut plan is given by

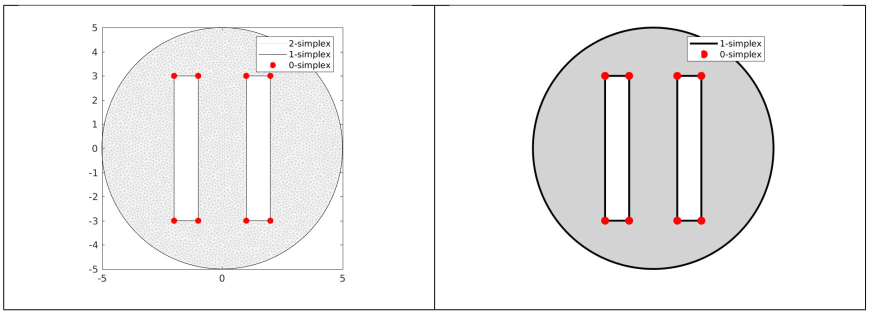
$$P(i,1)\,x + P(i,2)\,y + P(i,3)\,z + P(i,4) = 0.$$

The normal vector $P(i, 1:3)$ pointed to the part of the mesh not displayed. default : [] (no cut).

The options of second level depend on the type of elementaries mesh elements to represent.
One can use any option of the following functions according to the type of d-simplex to be represented.

- In dimension 3,
  - if $d == 3$, **patch** function is used,
  - if $d == 2$, trimesh function is used,
  - if $d == 1$, **plot3** function is used,
  - if $d == 0$, **plot3** function is used,
- In dimension 2,
  - if $d == 2$, trimesh or patch function is used,
  - if $d == 1$, **plot** function is used,
  - if $d == 0$, **plot** function is used,
- In dimension 1,
  - if $d == 1$, **line** function is used,
  - if $d == 0$, **plot** function is used,

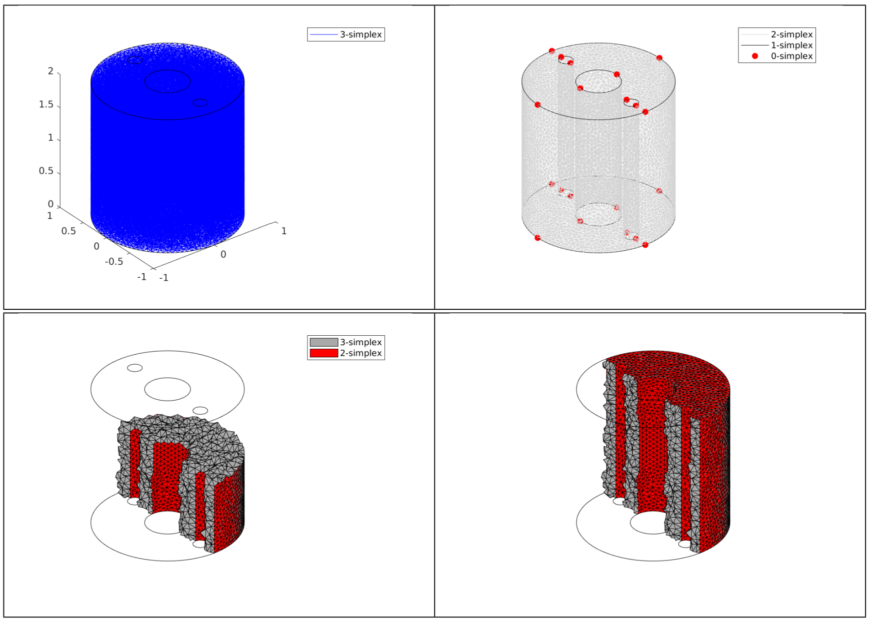
2D example




```
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh2D(2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh2D(1);
[q0,me0,toGlobal0]=fc_graphics4mesh.getMesh2D(0);
figure(1)
fc_graphics4mesh.plotmesh(q2,me2,'Color','LightGray','DisplayName','2-simplex')
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black','DisplayName','1-simplex')
fc_graphics4mesh.plotmesh(q0,me0,'color','red','DisplayName','0-simplex')
axis image
legend show

figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'fill',true,'Color','LightGray', ...
    'EdgeColor','None')
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black','Linewidth',2, ...
    'DisplayName','1-simplex')
fc_graphics4mesh.plotmesh(q0,me0,'color','red','markersize',8, ...
    'DisplayName','0-simplex')
axis image;axis off
legend show
```

Listing 1: 2D plot mesh

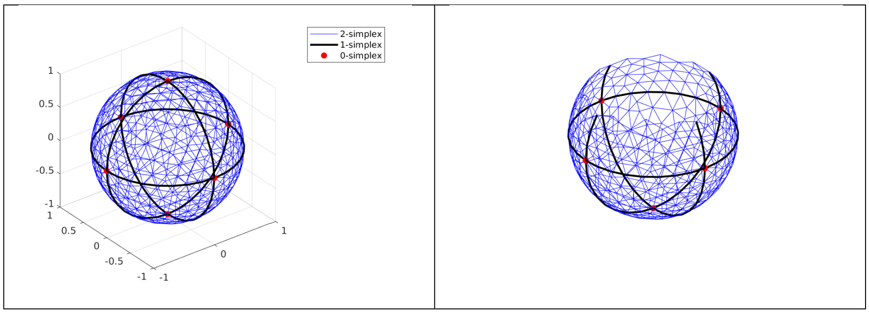
3D example




```
[q3,me3,toGlobal3]=fc_graphics4mesh.getMesh3D(3);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh3D(2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh3D(1);
[q0,me0,toGlobal0]=fc_graphics4mesh.getMesh3D(0);
figure(1)
view(3)
fc_graphics4mesh.plotmesh(q3,me3,'EdgeColor','blue','FaceColor','None', ...
    'DisplayName','3-simplex')
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black')
axis image
legend show

figure(2)
view(3)
fc_graphics4mesh.plotmesh(q2,me2,'EdgeColor','LightGray','FaceColor','None', ...
    'DisplayName','2-simplex')
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black','DisplayName','1-simplex')
fc_graphics4mesh.plotmesh(q0,me0,'color','red','DisplayName','0-simplex')
axis image;axis off
legend show

P=[fc_tools.graphics.PlaneCoefs([0 0 1], [0 0 1]); ...
    fc_tools.graphics.PlaneCoefs([0 0 1],[-1 0 0])];
figure(3)
fc_graphics4mesh.plotmesh(q1,me1,'color','black')
hold on
fc_graphics4mesh.plotmesh(q3,me3,'cutPlan',P,'Color','DarkGrey', ...
    'DisplayName','3-simplex')
fc_graphics4mesh.plotmesh(q2,me2,'cutPlan',P,'Color','red', ...
    'DisplayName','2-simplex')
axis image;axis off
legend show

P=fc_tools.graphics.PlaneCoefs([0 0 1], [-1 0 0]);
figure(4)
fc_graphics4mesh.plotmesh(q1,me1,'color','black')
hold on
fc_graphics4mesh.plotmesh(q3,me3,'cutPlan',P,'Color','DarkGrey')
fc_graphics4mesh.plotmesh(q2,me2,'cutPlan',P,'Color','red')
axis image; axis off
```

Listing 2: 3D plot mesh

3D surface example




```
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh3Ds(2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh3Ds(1);
[q0,me0,toGlobal0]=fc_graphics4mesh.getMesh3Ds(0);
figure(1)
view(3)
fc_graphics4mesh.plotmesh(q2,me2,'EdgeColor','blue','FaceColor','None', ...
    'DisplayName', '2-simplex')
hold on;axis image
fc_graphics4mesh.plotmesh(q1,me1,'color','black', ...
    'Linewidth',2,'DisplayName','1-simplex')
fc_graphics4mesh.plotmesh(q0,me0,'color','red','DisplayName','0-simplex')
legend show
P=fc_tools.graphics.PlaneCoefs([0 0 1/2], [0 0 1]);
figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'EdgeColor','blue','FaceColor','None','cutPlan',P)
hold on;axis image;axis off
fc_graphics4mesh.plotmesh(q1,me1,'color','black', 'Linewidth',2,'cutPlan',P)
fc_graphics4mesh.plotmesh(q0,me0,'color','red','cutPlan',P)
```

Listing 3: 3D surface mesh : plot function

5 PLOT function

The function PLOT displays data on a mesh given by its vertices array q and its connectivity array me.

Syntax

```
fc_graphics4mesh.plot(q,me,u)
fc_graphics4mesh.plot(q,me,u,Name,Value, ...)
```

Description

plot(q,me,u) displays data u on a simplicial mesh. The data u can be an handle function or an array.

plot(q,me,u,Name,Value, ...) specifies function options using one or more Name,Value pair arguments. Options of first level are

- `'cutPlan'` : (only for simplices in dimension 3) cut mesh by n plans given by n-by-4 array P where the equation of the i-th cut plan is given by

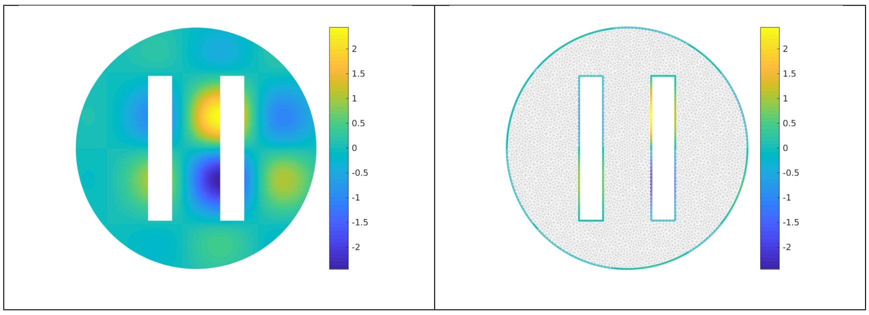
$$P(i,1)\,x + P(i,2)\,y + P(i,3)\,z + P(i,4) = 0.$$

The normal vector $P(i, 1:3)$ pointed to the part of the mesh not displayed. default : [] (no cut).

The options of second level depend on the type of elementaries mesh elements to represent.
One can use any option of the following functions according to the type of d-simplex to be represented.

- In dimension 3, **patch** function is used.
- In dimension 2,
  - if $d == 2$, **surf** or **patch** (option 'plan' to true) function is used,
  - if $d == 1$, **patch** function is used,
- In dimension 1, **plot** function is used.

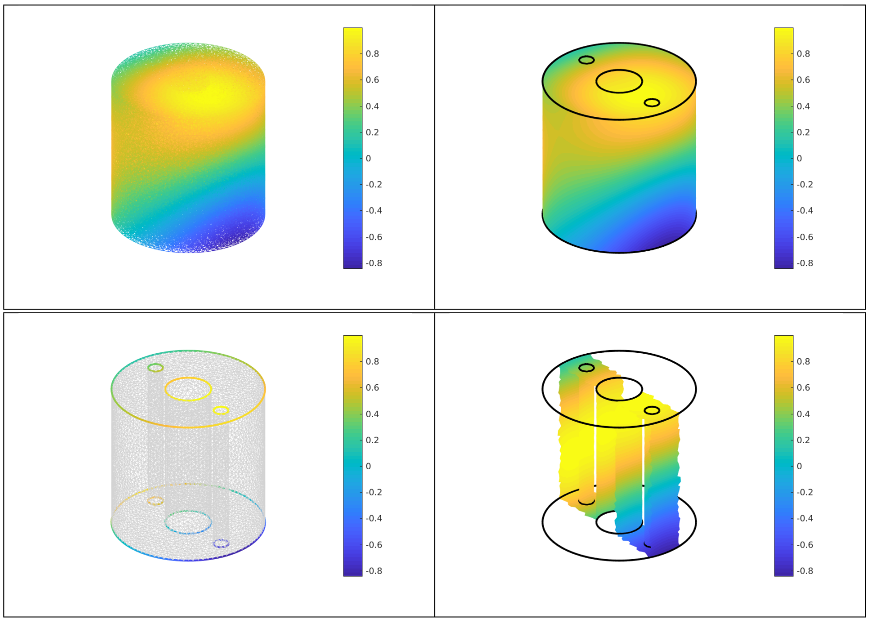
2D example




```
u=@(x,y) 3*exp(-((x-1).^2+y.^2)/10).*cos(x-1).*sin(y);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMeshArrays('2D',2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('2D',1);
U2=fc_graphics4mesh.evalAtVertices(u,q2);
figure(1)
fc_graphics4mesh.plot(q2,me2,U2,'plan',true)
shading interp
axis image;axis off
colorbar

figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray')
hold on
fc_graphics4mesh.plot(q1,me1,u,'LineWidth',2)
caxis([min(U2) max(U2)])
axis image;axis off
colorbar
```

Listing 4: Plot data on 2D mesh

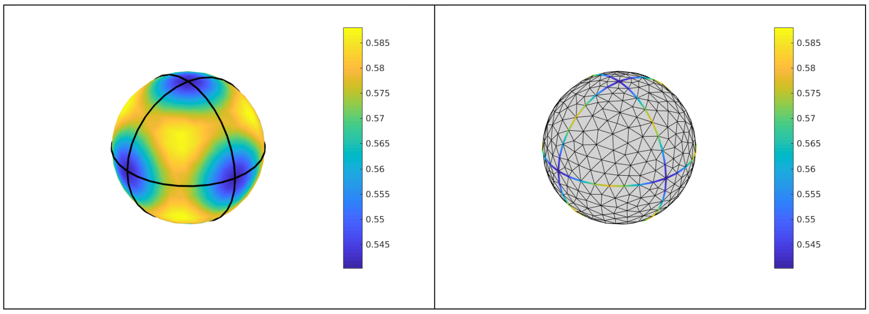
3D example




```
u=@(x,y,z) cos(x).*sin(y+z);
[q3,me3,toGlobal3]=fc_graphics4mesh.getMeshArrays('3D',3);
U3=fc_graphics4mesh.evalAtVertices(u,q3);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMeshArrays('3D',2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('3D',1);

figure(1)
fc_graphics4mesh.plot(q3,me3,U3)
shading interp
axis image; axis off
colorbar

figure(2)
fc_graphics4mesh.plot(q2,me2,U3(toGlobal2))
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black','LineWidth',2)
shading interp
axis image; axis off
caxis([min(U3),max(U3)])
colorbar

figure(3)
fc_graphics4mesh.plotmesh(q2,me2,'EdgeColor','LightGray','FaceColor','None')
hold on
fc_graphics4mesh.plot(q1,me1,u,'LineWidth',2)
axis image; axis off
caxis([min(U3),max(U3)])
colorbar

P=[fc_tools.graphics.PlaneCoefs([0.2 0 1], [1 0 0]); ...
    fc_tools.graphics.PlaneCoefs([-0.2 0 1], [-1 0 0])];
figure(4)
fc_graphics4mesh.plot(q2,me2,U3(toGlobal2),'cutPlan',P)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black','LineWidth',2)
shading interp
axis image; axis off
caxis([min(U3),max(U3)])
colorbar
```

Listing 5: Plot data on 3D mesh

3D surface example




```
u=@(x,y,z) cos(x).*cos(y).*cos(z);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh3Ds(2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh3Ds(1);
U2=fc_graphics4mesh.evalAtVertices(u,q2);
U1=fc_graphics4mesh.evalAtVertices(u,q1);
figure(1)
fc_graphics4mesh.plot(q2,me2,U2)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','k','LineWidth',2)
shading interp
axis image;axis off
colorbar
figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray')
hold on
fc_graphics4mesh.plot(q1,me1,U1,'LineWidth',2)
axis image;axis off
caxis([min(U2),max(U2)])
colorbar
P=fc_tools.graphics.PlaneCoefs([0 0 0], [0 0 1]);
figure(3)
fc_graphics4mesh.plot(q2,me2,U2,'cutPlan',P)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','k','LineWidth',2)
shading interp
axis image;axis off
caxis([min(U2),max(U2)])
colorbar
figure(4)
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray','cutPlan',P)
hold on
fc_graphics4mesh.plot(q1,me1,U1,'LineWidth',2,'cutPlan',P)
axis image;axis off
caxis([min(U2),max(U2)])
colorbar
```

Listing 6: 3D surface mesh : plot function

6 PLOTISO function

The function PLOT displays isolines from datas on a 2-simplicial mesh given by its vertices array q and its connectivity array me.

Syntax

```
fc_graphics4mesh.plotiso(q,me,u)
fc_graphics4mesh.plotiso(q,me,u,Name,Value, ...)
```

Description

plotiso(q,me,u) displays isolines from datas on the 2-simplicial mesh given by the vertices array q and the connectivity array me. The data u can be an handle function or an array.

plotiso (q,me,u,Name,Value, ...) specifies function options using one or more Name,Value pair arguments. Options of first level are

- `'niso'` : to specify the number of isolines (default : 10)
- `'isorange'` : to specify the list of isovalues (default : empty)
- `'isocolorbar'` : if true, colorbar with isovalues is drawn (default : false)
- `'format'` : to specify the format of the isovalues on the colorbar (default : '%g')
- `'plan'` : if true, (default : false)
- `'color'` : to specify one color for all isolines (default : empty)
- `'mouse'` : if true, display information on clicked isoline (default : true)

The options of second level are all options of

- **plot3** function in dimension 3 or in dimension 2 with `'plan'` set to false
- **plot** function in 2 with `'plan'` set to true

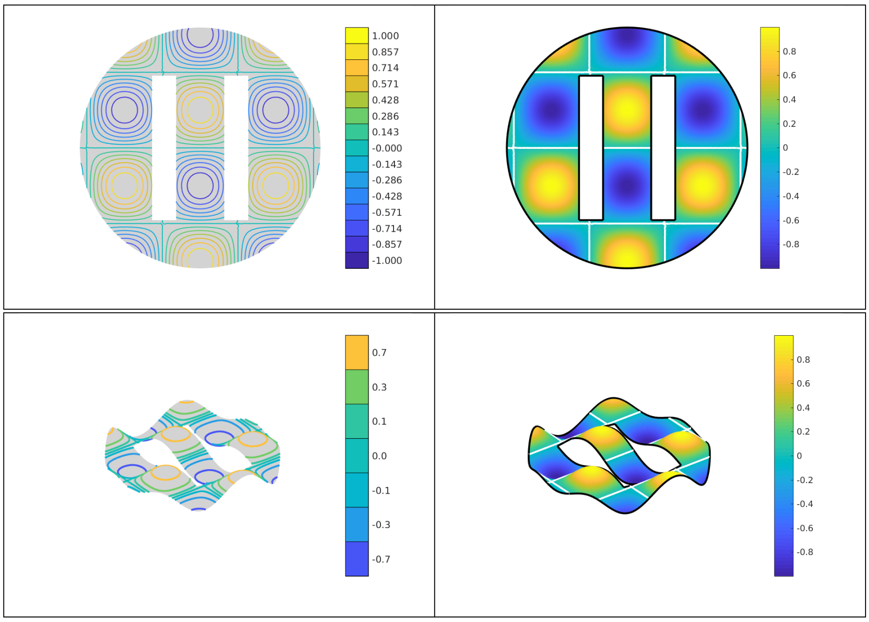
This function accepts until 3 output arguments :

$_bullet$ 1st output is the colors of the isolines

$_bullet$ 2nd output is the isovalues of the isolines

$_bullet$ 3th output is all the handles of the isolines as an 2D-array of dimension N-by-niso, where N is the number of 2-simplex elementary meshes where isolines are drawn.

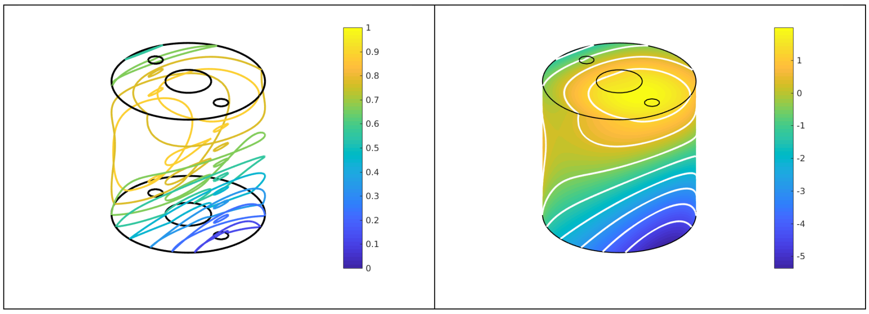
2D example




```
u=@(x,y) cos(x).*sin(y);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh2D(2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh2D(1);
U2=fc_graphics4mesh.evalAtVertices(u,q2);
U1=fc_graphics4mesh.evalAtVertices(u,q1);

figure(1)
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray','fill',true, ...
     'EdgeColor','None','FaceColor','LightGray')
hold on
fc_graphics4mesh.plotiso(q2,me2,U2,'plan',true, ...
     'niso',15,'isocolorbar',true,'format','%.3f','LineWidth',1)
axis image;axis off

figure(2)
fc_graphics4mesh.plot(q2,me2,U2,'plan',true)
hold on
fc_graphics4mesh.plotiso(q2,me2,U2,'plan',true, ...
     'Color','w','isorange',0,'LineWidth',2)
fc_graphics4mesh.plotmesh(q1,me1, 'LineWidth',2, 'Color','k')
colorbar
shading interp
axis image;axis off

figure(3)
fc_graphics4mesh.plotmesh(q2,me2,'z',U2,'fill',true,'Color','LightGray')
hold on
isorange=[-0.7,-0.3,-0.1,0,0.1,0.3,0.7];
fc_graphics4mesh.plotiso(q2,me2,U2,'LineWidth',2, ...
     'isorange',isorange,'isocolorbar',true,'format','%.1f')
axis image;axis off
figure(4)
fc_graphics4mesh.plot(q2,me2,U2)
hold on
fc_graphics4mesh.plotiso(q2,me2,U2,'LineWidth',2, ...
     'Color','w','isorange',0,'LineWidth',2)
fc_graphics4mesh.plotmesh(q1,me1,'z',U1,'LineWidth',2, 'Color','k')
axis image;axis off
shading interp
colorbar
```

Listing 7: Isolines on a 2D mesh

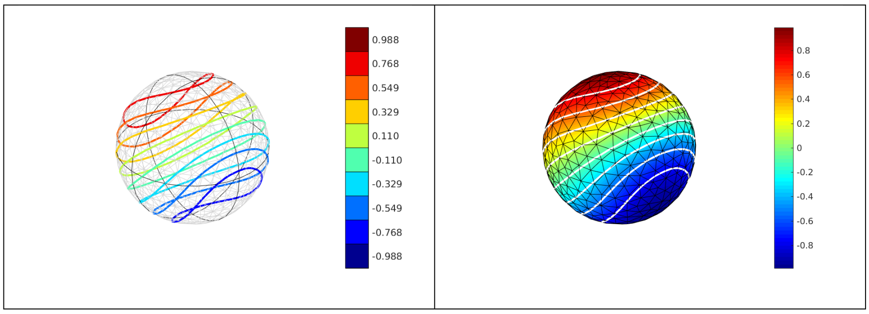
3D example




```
u=@(x,y,z) -2+4*cos(x).*sin(y+z);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMeshArrays('3D',2);
U2=fc_graphics4mesh.evalAtVertices(u,q2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('3D',1);
U1=fc_graphics4mesh.evalAtVertices(u,q1);
figure(1)
fc_graphics4mesh.plotmesh(q1,me1,'color','black','LineWidth',2)
hold on
fc_graphics4mesh.plotiso(q2,me2,U2,'LineWidth',2)
colorbar
shading interp
axis image;axis off
figure(2)
fc_graphics4mesh.plot(q2,me2,U2)
hold on
fc_graphics4mesh.plotiso(q2,me2,U2,'color','white','LineWidth',2)
fc_graphics4mesh.plotmesh(q1,me1,'color','black','LineWidth',1)
shading interp
axis image;axis off
colorbar
```

Listing 8: Isolines on surfaces of a 3D mesh

3D surface example




```
u=@(x,y,z) cos(x).*sin(y+z);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMeshArrays('3Ds',2);
U2=fc_graphics4mesh.evalAtVertices(u,q2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('3Ds',1);
figure(1)
colormap('jet')
fc_graphics4mesh.plotmesh(q2,me2,'EdgeColor','LightGray','FaceColor','None')
hold on
fc_graphics4mesh.plotmesh(q1,me1,'Color','black')
fc_graphics4mesh.plotiso(q2,me2,U2,'isocolorbar',true,'format','%.3f', ...
    'LineWidth',2)
axis image;axis off
figure(2)
colormap('jet')
fc_graphics4mesh.plot(q2,me2,U2)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'Color','black')
fc_graphics4mesh.plotiso(q2,me2,U2,'LineWidth',2,'Color','w')
colorbar
axis image;axis off
```

Listing 9: 3D surface mesh : plotiso function

7 SLICEMESH function

The SLICEMESH function displays intersection of a plane and a 3D mesh given by its vertices array q and its connectivity array me.

Syntaxe

```
fc_graphics4mesh.slicemesh(q,me,P)
fc_graphics4mesh.slicemesh(q,me,P,Name,Value, ...)
```

Description

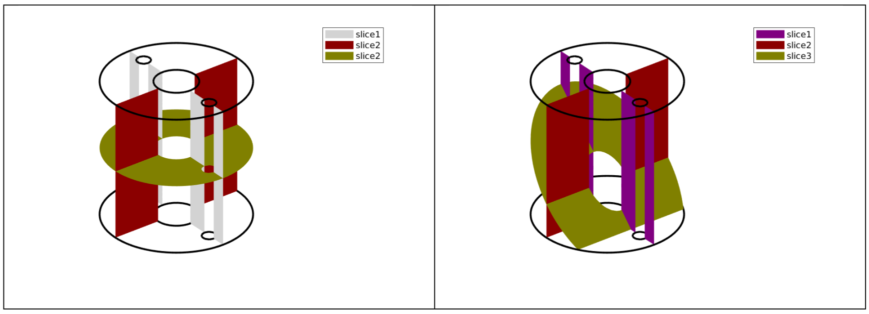
slicemesh(q,me,P) displays intersection of the plane defined by $P(1)x+P(2)y+P(3)z+P(4)=0$ and all the 3-dimensional simplices elements given by q and me arrays. To compute P one can use the fc_tools.graphics.PlaneCoefs function of the FC-TOOLS toolbox. The 1-by-4 array P, is obtained with P=fc_tools.graphicsPlaneCoefs(Q,V) where Q is a point in the plane and V is a vector orthogonal to it. One can also used a n-by-4 array P where each line define a plane.

slicemesh(q,me,P,Name,Value, ...) specifies function options using one or more Name,Value pair arguments. Options of first level are

- **'color'** : to specify the slice color (default : 'LightGray', rgb=[0.9,0.9,0.9])

The options of second level are all options of the **patch** function except **'FaceColor'** and **'EdgeColor'**

3D example




```
[q3,me3,toGlobal3]=fc_graphics4mesh.getMeshArrays('3D',3);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('3D',1);
figure(1)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[1 0 0]);% ...
fc_graphics4mesh.slicemesh(q3,me3,P,'DisplayName','slice1')
hold on
P=fc_tools.graphics.PlaneCoefs([0 0 1],[0 1 0]);% ...
fc_graphics4mesh.slicemesh(q3,me3,P,'Color','DarkRed','DisplayName','slice2')
P=fc_tools.graphics.PlaneCoefs([0 0 1],[0 0 1]);% ...
fc_graphics4mesh.slicemesh(q3,me3,P,'Color','Olive','DisplayName','slice2')
fc_graphics4mesh.plotmesh(q1,me1,'color','k', 'LineWidth',2)
axis off; axis image
legend('show')
figure(2)
P=[fc_tools.graphics.PlaneCoefs([0 0 1/2],[1 0 0]); ...
     fc_tools.graphics.PlaneCoefs([0 0 1/2],[0 1 0]); ...
     fc_tools.graphics.PlaneCoefs([0 0 1/2],[0 -1 1])];
fc_graphics4mesh.slicemesh(q3,me3,P, 'Color',{'Purple','DarkRed','Olive'}, ...
     'DisplayName',{'slice1','slice2','slice3'})
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','k', 'LineWidth',2)
axis off; axis image
legend('show')
```

Listing 10: 3D mesh : slicemesh function

8 SLICE function

The SLICE function displays intersection of a plane and a 3D mesh given by its vertices array q and its connectivity array me.

Syntaxe

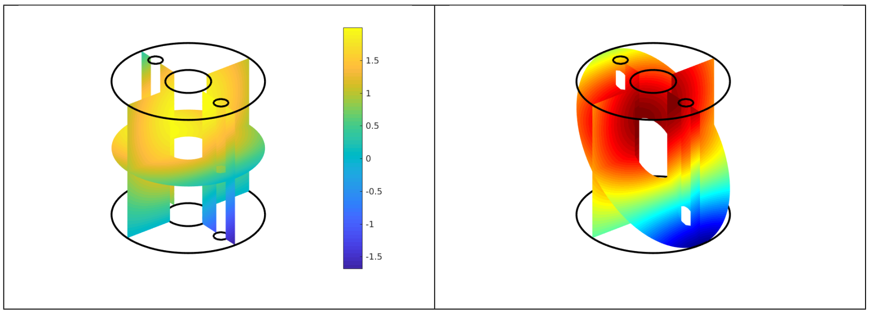
```
fc_graphics4mesh.slice(q,me,u,P)
fc_graphics4mesh.slice(q,me,u,P,Name,Value, ...)
```

Description

slice(q,me,u,P) displays data on the intersection of the plane defined by $P(1)x + P(2)y + P(3)z + P(4) = 0$ and all the 3-dimensional simplices elements given by q and me arrays. To compute P one can use the fc_tools.graphics.PlaneCoefs function of the FC-TOOLS toolbox. The array P, is obtained with P=fc_tools.graphicsPlaneCoefs(Q,V) where Q is a point in the plane and V is a vector orthogonal to it. One can also used a n-by-4 array P where each line define a plane.

slice(q,me,u,P,Name,Value, ...) specifies function options using one or more Name,Value pair arguments which are those of the **patch** function excepts `'FaceColor'` and `'EdgeColor'`.

3D example




```
u=@(x,y,z) 2*cos(x).*sin(y+z);
[q3,me3,toGlobal3]=fc_graphics4mesh.getMeshArrays('3D',3);
U3=fc_graphics4mesh.evalAtVertices(u,q3);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('3D',1);
figure(1)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[1 0 0]);
fc_graphics4mesh.slicemesh(q3,me3,P)
hold on
fc_graphics4mesh.slice(q3,me3,U3,P)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[0 1 0]);
fc_graphics4mesh.slice(q3,me3,U3,P)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[0 0 1]);% ...
fc_graphics4mesh.slice(q3,me3,U3,P)
fc_graphics4mesh.plotmesh(q1,me1,'color','k', 'LineWidth',2)
axis off; axis image
colorbar
figure(2)
P=[fc_tools.graphics.PlaneCoefs([0 0 1],[1 0 0]); ...
    fc_tools.graphics.PlaneCoefs([0 0 1],[0 1 0]); ...
    fc_tools.graphics.PlaneCoefs([0 0 1],[0 -1 1])];
colormap('jet')
fc_graphics4mesh.slice(q3,me3,u,P)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','k', 'LineWidth',2)
axis off; axis image
```

Listing 11: 3D mesh : **slice** function

9 SLICEISO function

The SLICEISO function displays isolines of datas on the intersection of a plane and a 3D mesh given by its vertices array q and its connectivity array me.

Syntaxe

```
fc_graphics4mesh.sliceiso(q,me,u,P)
fc_graphics4mesh.sliceiso(q,me,u,P,Name,Value, ...)
```

Description

sliceiso (q,me,u,P) displays isolines of data u on the intersection of the plane defined by $P(1)x + P(2)y + P(3)z + P(4) = 0$ and all the 3-dimensional simplices elements given by q and me arrays. To compute P one can use the fc_tools.graphics.PlaneCoefs function of the FC-TOOLS toolbox. The 1-by-4 array P, is obtained with P=fc_tools.graphicsPlaneCoefs(Q,V) where Q is a point in the plane and V is a vector orthogonal to it. One can also used a n-by-4 array P where each line define a plane.

sliceiso (q,me,u,P,Name,Value, ...) allows additional key/value pairs to be used when displaying u. The key strings could be

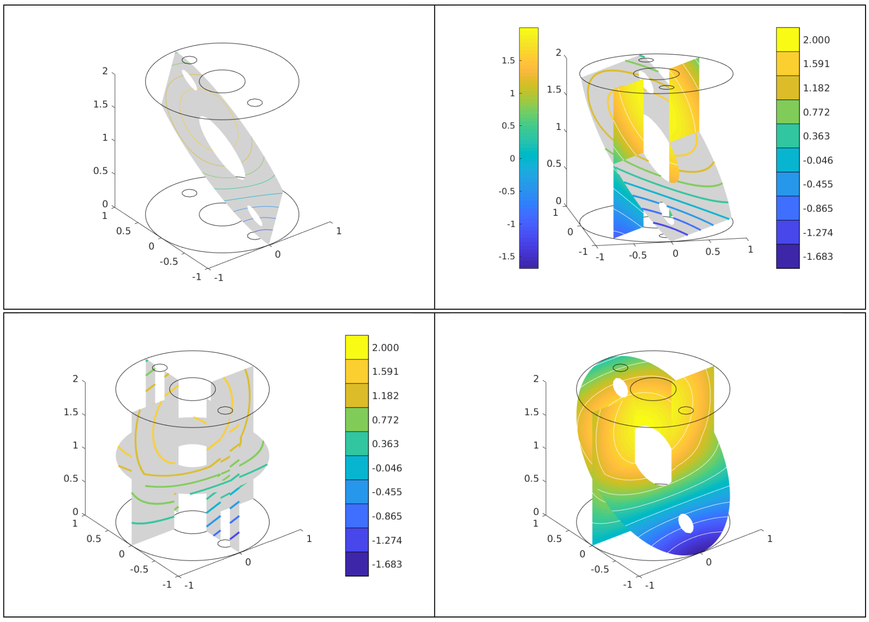
- `'niso'` : to specify the number of isolines (default : 10)
- `'isorange'` : to specify the list of isovalues (default : empty)
- `'color'` : to specify one color for all isolines (default : empty)
- `'isocolorbar'` : if true display a colorbar.Default is false.
- `'format'` : to specify the format of the isovalues print in the colorbar. Default is `'%g'`.
- `'mouse'` : if true, display information on clicked isoline (default : true)

For key strings, one could also used any options of the plot3 function.

This function accepts until 4 output arguments :

- 1st output is the colors of the isolines
- 2nd output is the isovalues of the isolines
- 3th output is the handle of the colobar iso.
- 4th output is all the handles of the isolines as an 2D-array of dimension N-by-niso, where N is the number of elementary meshes where isolines are drawn.

3D example




```
u=@(x,y,z) 2*cos(x).*sin(y+z);
[q3,me3,toGlobal3]=fc_graphics4mesh.getMeshArrays('3D',3);
U3=fc_graphics4mesh.evalAtVertices(u,q3);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMeshArrays('3D',1);
figure(1)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[1 -1 1]);
fc_graphics4mesh.slicemesh(q3,me3,P)
hold on;axis equal;axis image
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P)
figure(2)
fc_graphics4mesh.slicemesh(q3,me3,P)
hold on;axis equal;axis image
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'Linewidth',2, ...
     'isocolorbar',true,'format','%.3f');
P=fc_tools.graphics.PlaneCoefs([0 0 1],[1 -1 0]);
fc_graphics4mesh.slice(q3,me3,U3,P)
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'color','w');
colorbar('Location','westoutside')
caxis([min(U3),max(U3)]);view(-11,15)
figure(3)
P=[fc_tools.graphics.PlaneCoefs([0 0 1],[1 0 0]); ...
   fc_tools.graphics.PlaneCoefs([0 0 1],[0 1 0]); ...
   fc_tools.graphics.PlaneCoefs([0 0 1],[0 0 1])];
fc_graphics4mesh.slicemesh(q3,me3,P)
hold on;axis equal;axis image
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'LineWidth',2, ...
     'isocolorbar',true,'format','%.3f');
figure(4)
P=[fc_tools.graphics.PlaneCoefs([0 0 1],[0 1 0]); ...
   fc_tools.graphics.PlaneCoefs([0 0 1],[0 -1 1])];
fc_graphics4mesh.slice(q3,me3,U3,P)
hold on;axis equal;axis image
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'Color','w');
```

Listing 12: 3D mesh : sliceiso function

10 PLOTQUIVER function

The function PLOTQUIVER displays vector field datas on a mesh given by its vertices array q and its connectivity array me.

Syntax

```
fc_graphics4mesh.plotquiver(q,me,V)
fc_graphics4mesh.plotquiver(q,me,V,Name,Value, ...)
```

Description

plotquiver(q,me,V) displays vector field u on a simplicial mesh. The vector field data u can be a 1-by-dim cell arrays of handle functions or an dim-by-n_q array.

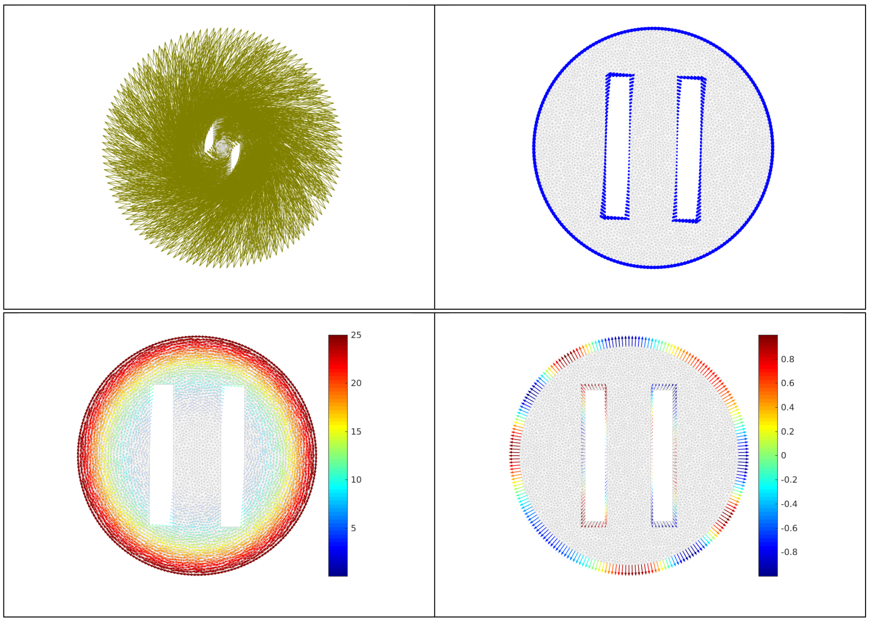
plotquiver(q,me,V,Name,Value, ...) specifies function options using one or more Name,Value pair arguments. Options of first level are

- `'freq'` : quiver frequencie, (default : 1)
- `'scale'` : quiver scale, (default is fc_graphics4mesh.getCharacteristicLength(q)/20)
- `'color'` : set one color for all quivers (default: default color of the **quiver** or quiver3 functions). Cannot be used with `'colordata'` option.
- `'colordata'` : each quiver is colorized with a 1-by-nq array or a handle function (it will evaluated in all vertices) (default : empty).

The options of second level depend on the type of mesh elements to represent.
One can use any option of the following functions according to the type of d-simplex to be represented.

- In dimension 3 and with empty `'colordata'` , the quiver3 function is used.
- In dimension 2 and with empty `'colordata'` , the **quiver** function is used.
- In dimension 2 or 3 and with no empty `'colordata'`, the third party fc_tools.graphics.vfield3.vfield3 function is used.

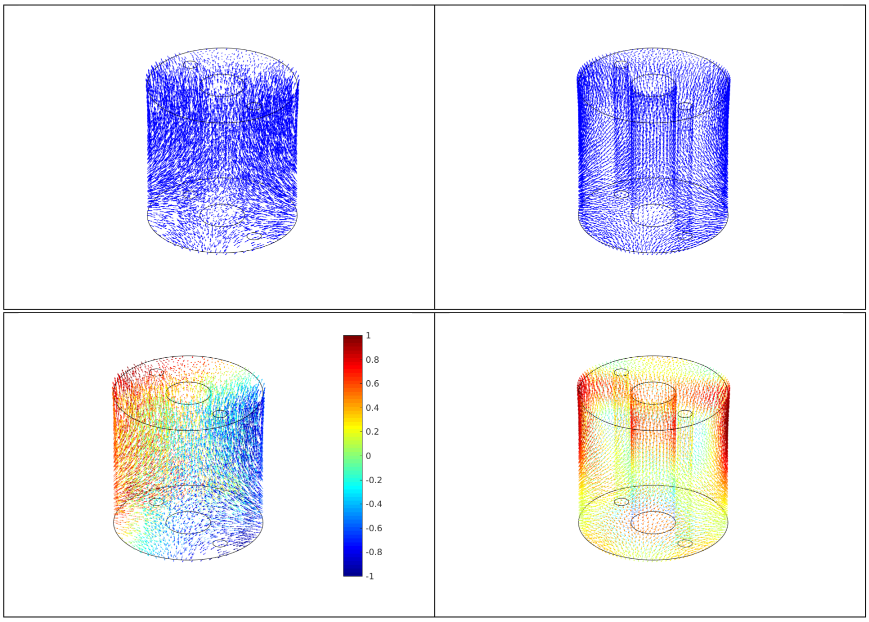
2D example




```
v={@(x,y) y.*sqrt(x.^2+y.^2),@(x,y) -x.*sqrt(x.^2+y.^2)};
vv={@(x,y) x/5,@(x,y) y/5};
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh2D(2);
V2=fc_graphics4mesh.evalAtVertices(v,q2);
u2=sqrt(V2{1}.^2+V2{2}.^2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh2D(1);
V1=fc_graphics4mesh.evalAtVertices(v,q1);
VV1=fc_graphics4mesh.evalAtVertices(vv,q1);
u1=sqrt(V1{1}.^2+V1{2}.^2);
figure(1)
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray')
hold on
fc_graphics4mesh.plotquiver(q2,me2,V2, 'color','Olive','freq',2,'scale',0.5)
axis image;axis off
figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray')
hold on
fc_graphics4mesh.plotquiver(q1,me1,V1,'LineWidth',2)
axis image;axis off
figure(3)
colormap('jet')
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray')
hold on
fc_graphics4mesh.plotquiver(q2,me2,V2,'colordata',u2)
axis image;axis off
colorbar
figure(4)
colormap('jet')
fc_graphics4mesh.plotmesh(q2,me2,'color','LightGray')
hold on
fc_graphics4mesh.plotquiver(q1,me1,VV1,'LineWidth',2,'colordata',@(x,y) sin(x+y))
axis image;axis off
colorbar
```

Listing 13: Plot quiver on 2D mesh

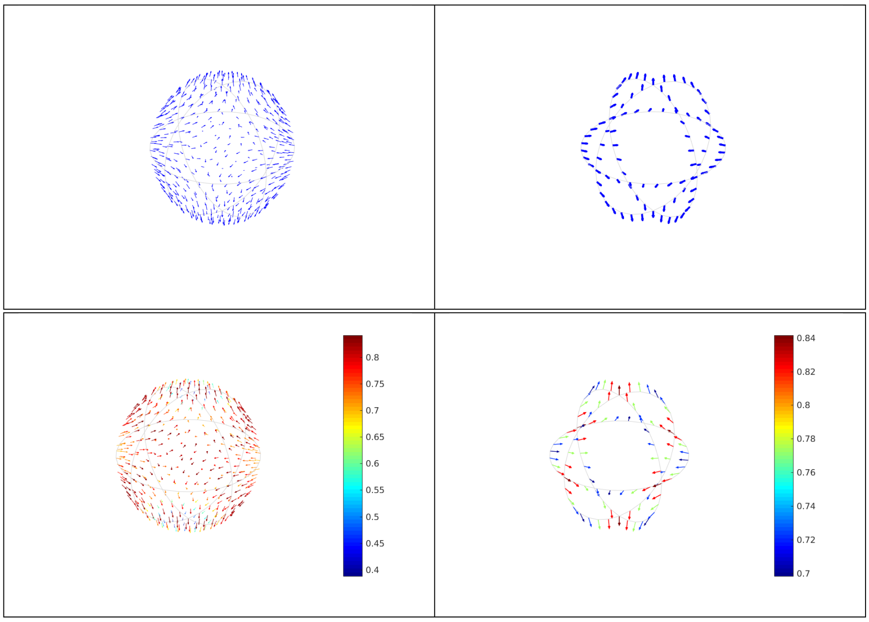
3D example




```
v={@(x,y,z) cos(x+z).*sin(y),@(x,y,z) sin(x).*cos(z+y),@(x,y,z) sin(z).*cos(x+y)};
[q3,me3,toGlobal3]=fc_graphics4mesh.getMesh3D(3);
V3=fc_graphics4mesh.evalAtVertices(v,q3);
fu3=@(x,y,z) y;
u3=fc_graphics4mesh.evalAtVertices(fu3,q3);
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh3D(2);
V2=fc_graphics4mesh.evalAtVertices(v,q2);
u2=sqrt(V2{1}.^2+V2{2}.^2+V2{3}.^2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh3D(1);
V1=fc_graphics4mesh.evalAtVertices(v,q1);
u1=sqrt(V1{1}.^2+V1{2}.^2+V1{3}.^2);
figure(1)
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
hold on;axis image;axis off
fc_graphics4mesh.plotquiver(q3,me3,V3,'freq',2)
figure(2)
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
hold on;axis image;axis off
fc_graphics4mesh.plotquiver(q2,me2,V2)
figure(3)
colormap('jet')
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
hold on;axis image;axis off
fc_graphics4mesh.plotquiver(q3,me3,V3,'colordata',u3, 'freq',2)
colorbar
figure(4)
colormap('jet')
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
hold on;axis image;axis off
fc_graphics4mesh.plotquiver(q2,me2,V2, 'colordata',u2)%,'scale',1)
```

Listing 14: Plot quivers on 3D mesh

3D surface example




```
v={@(x,y,z) cos(x+z).*sin(y),@(x,y,z) sin(x).*cos(z+y),@(x,y,z) sin(z).*cos(x+y)};
[q2,me2,toGlobal2]=fc_graphics4mesh.getMesh3Ds(2);
V2=fc_graphics4mesh.evalAtVertices(v,q2);
u2=sqrt(V2{1}.^2+V2{2}.^2+V2{3}.^2);
[q1,me1,toGlobal1]=fc_graphics4mesh.getMesh3Ds(1);
V1=fc_graphics4mesh.evalAtVertices(v,q1);
u1=sqrt(V1{1}.^2+V1{2}.^2+V1{3}.^2);
figure(1)
fc_graphics4mesh.plotmesh(q1,me1,'color','LightGray')
hold on
fc_graphics4mesh.plotquiver(q2,me2,V2)
axis image;axis off
figure(2)
fc_graphics4mesh.plotmesh(q1,me1,'color','LightGray')
hold on
fc_graphics4mesh.plotquiver(q1,me1,V1,'LineWidth',2)
axis image;axis off
figure(3)
colormap('jet')
fc_graphics4mesh.plotmesh(q1,me1,'color','LightGray')
hold on;axis image;axis off
fc_graphics4mesh.plotquiver(q2,me2,V2,'colordata',u2)
colorbar
figure(4)
colormap('jet')
fc_graphics4mesh.plotmesh(q1,me1,'color','LightGray')
hold on;axis image;axis off
fc_graphics4mesh.plotquiver(q1,me1,V1,'LineWidth',2,'colordata',u1, 'scale',0.2)
colorbar
```

Listing 15: 3D surface mesh : plot quivers function