



**fc-graphics4mesh** Matlab toolbox, User's Guide\*  
version 0.1.2

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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.

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\* $\text{\LaTeX}$  manual, revision 0.1.2, compiled with Matlab 2019a, and toolboxes `fc-graphics4mesh[0.1.2]`, `fc-tools[0.0.31]`, `fc-bench[0.1.2]`, `fc-amat[0.1.2]`, `fc-meshtools[0.1.3]`

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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 on various OS with Matlab releases:

Operating system	2017a	2017b	2018a	2018b	2019a
CentOS 7.7.1908	✓	✓	✓	✓	✓
Debian 9.11	✓	✓	✓	✓	✓
Fedora 29	✓	✓	✓	✓	✓
OpenSUSE Leap 15.0	✓	✓	✓	✓	✓
Ubuntu 18.04.3 LTS	✓	✓	✓	✓	✓
MacOS High Sierra 10.13.6	✓	✓	✓	✓	✓
MacOS Mojave 10.14.4	✓	✓	✓	✓	✓
MacOS Catalina 10.15.2	✓	✓	✓	✓	✓
Windows 10 (1909)	✓	✓	✓	✓	✓

It is not compatible with Matlab releases prior to R2015b.

## 2 Installation

### 2.1 Installation automatic, all in one (recommended)

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` directory, one have to copy the file `mfc_graphics4mesh_install.m` in the `~/Matlab` directory. Then in a Matlab terminal run the following commands

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

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

```
Parts of the <fc-graphics4mesh> Matlab toolbox.
Copyright (C) 2017-2020 F. Cuvelier

1- Downloading and extracting the toolboxes
2- Setting the <fc-graphics4mesh> toolbox
Write in ...
   ~/Matlab/fc-graphics4mesh-full/fc_graphics4mesh-0.1.2/configure_loc.m ...
   ...
3- Using toolboxes :
->          fc-tools : 0.0.31
->          fc-bench : 0.1.2
->          fc-amat  : 0.1.2
->          fc-meshtools : 0.1.3
with      fc-graphics4mesh : 0.1.2
*** Using instructions
To use the <fc-graphics4mesh> toolbox:
addpath('~/Matlab/fc-graphics4mesh-full/fc_graphics4mesh-0.1.2')
fc_graphics4mesh.init()

See ~/Matlab/mfc_graphics4mesh_set.m
```

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

```
>> addpath('~/Matlab/fc-graphics4mesh-full/fc_meshtools.0.1.2')
>> fc_graphics4mesh.init()
```

If it's the first time the `fc_meshtools.init()` function is used, then its output is

```

Try to use default parameters!
Use fc_tools.configure to configure.
Write in ...
  /home/cuvelier/tmp/fc-graphics4mesh-full/fc_tools-0.0.31/configure_loc.m ...
...
Try to use default parameters!
Use fc_bench.configure to configure.
Write in ...
  /home/cuvelier/tmp/fc-graphics4mesh-full/fc_bench-0.1.2/configure_loc.m ...
...
Try to use default parameters!
Use fc_amat.configure to configure.
Write in ...
  /home/cuvelier/tmp/fc-graphics4mesh-full/fc_amat-0.1.2/configure_loc.m ...
...
Try to use default parameters!
Use fc_meshtools.configure to configure.
Write in ...
  /home/cuvelier/tmp/fc-graphics4mesh-full/fc_meshtools-0.1.3/configure_loc.m ...
...
Using fc_graphics4mesh[0.1.2] with fc_tools[0.0.31], fc_bench[0.1.2], ...
fc_amat[0.1.2], fc_meshtools[0.1.3].

```

Otherwise, the output of the `fc_meshtools.init()` function is

```

Using fc_graphics4mesh[0.1.2] with fc_tools[0.0.31], fc_bench[0.1.2], ...
fc_amat[0.1.2], fc_meshtools[0.1.3].

```

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

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

## 2.2 Manual installation

This package uses the `fc_mesh` 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`. The toolbox path is `~/Matlab/mfc-graphics4mesh-0.1.2`
- Adds the toolbox path in Matlab with `addpath` command.
- Verifies that the `fc_tools`, `fc_bench`, `fc_amat` and `fc_meshtools` toolboxes are 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- $n_q$  array where  $dim$  is the space dimension (2 or 3) and  $n_q$  the number of vertices. The connectivity array  $me$  is a  $(d + 1)$ -by- $n_{me}$  array where  $n_{me}$  is the number of mesh elements and  $0 \leq d \leq dim$  is the simplicial dimension:

- $d = 0$ : points,

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

So we can use these 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_meshtools.simplicial.getMesh3D(3)` return a 3-simplicial mesh (*main* mesh) in space dimension  $dim = 3$ ,
- `[q2,me2,toGlobal2]=fc_meshtools.simplicial.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 `fc_graphics4mesh.plotmesh` function

The function `fc_graphics4mesh.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'`),
- `'cutPlane'` : (only for simplices in dimension 3) cut mesh by  $n$  planes given by  $n$ -by-4 array  $P$  where the equation of the  $i$ -th cut plane 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).

- `'inLegend'` : to add this mesh in a legend if `true`. Default is `false`.

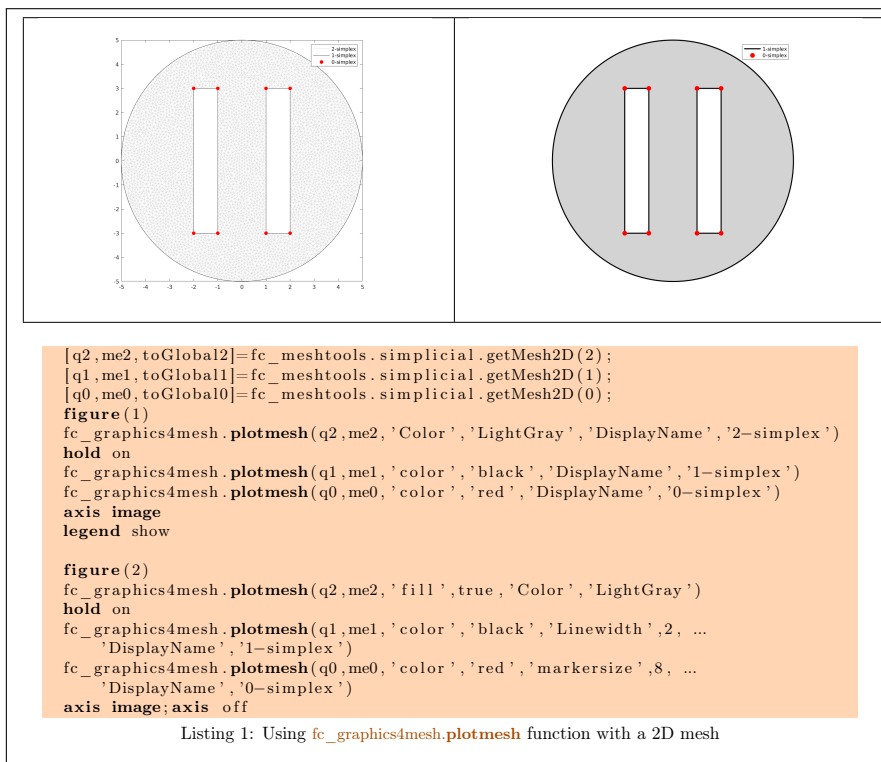
- **'DisplayName'** : to specify the name used in a legend for this mesh.  
Then the (**'inLegend'** option is forced to **true**).

The options of second level depend on the type of elementary mesh elements to represent.

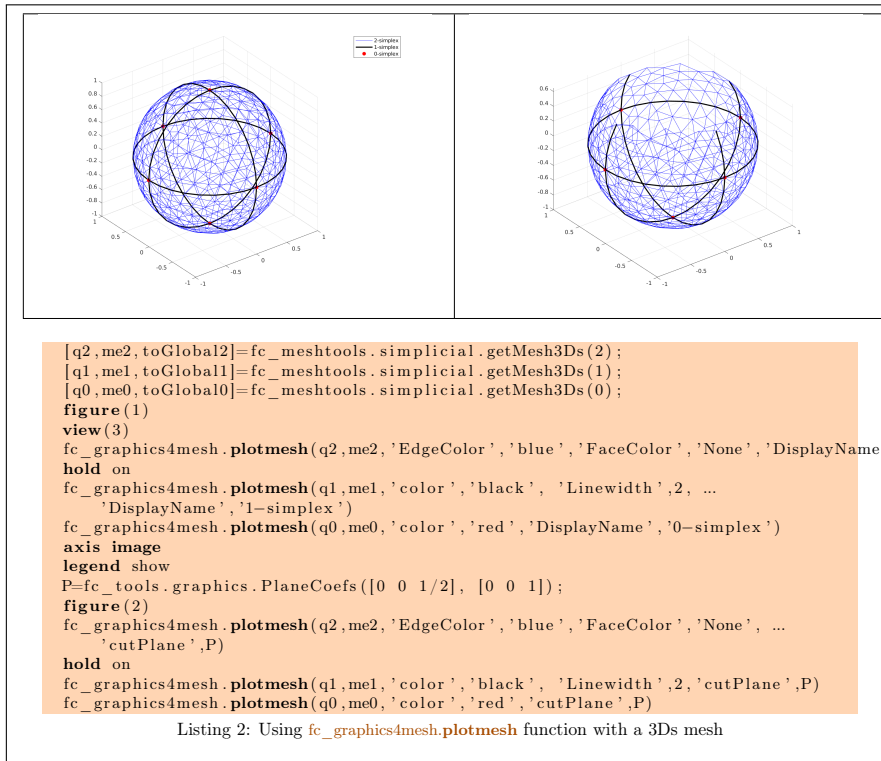
One can use any option of the following functions according to the type of  $d$ -simplex to be represented.

- 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,

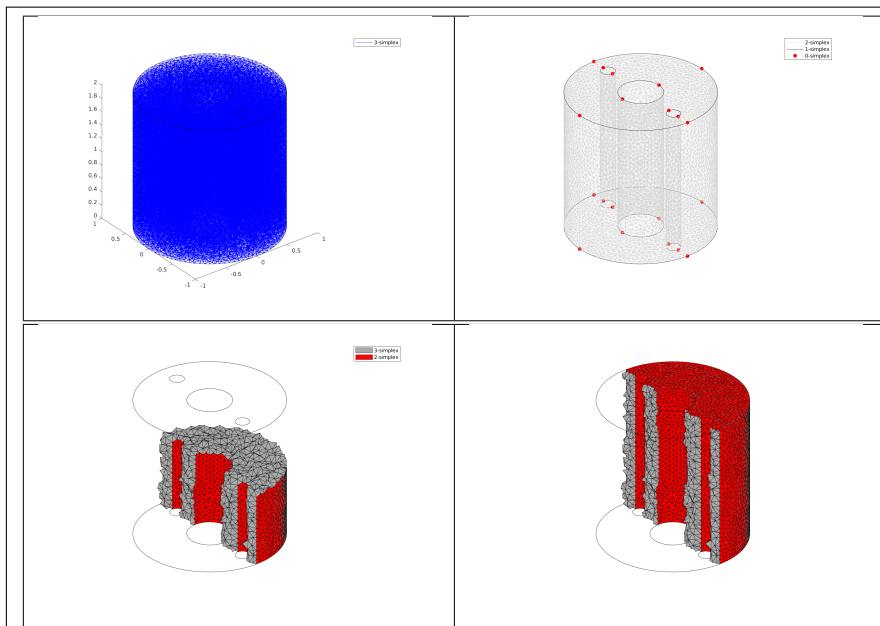
**2D example :** the following code is part of the `fc_graphics4mesh.demos.plotmesh2D` function.



**3Ds example :** the following code is part of the `fc_graphics4mesh.demos.plotmesh3Ds` function.



**3D example :** the following code is part of the `fc_graphics4mesh.demos.plotmesh3D` function.



```

[q3,me3,toGlobal3]=fc_meshtools.simplicial.getMesh3D(3);
[q2,me2,toGlobal2]=fc_meshtools.simplicial.getMesh3D(2);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.getMesh3D(1);
[q0,me0,toGlobal0]=fc_meshtools.simplicial.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,'cutPlane',P,'Color','DarkGrey', ...
    'DisplayName','3-simplex')
fc_graphics4mesh.plotmesh(q2,me2,'cutPlane',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,'cutPlane',P,'Color','DarkGrey')
fc_graphics4mesh.plotmesh(q2,me2,'cutPlane',P,'Color','red')

```

Listing 3: Using `fc_graphics4mesh.plotmesh` function with a 3D mesh



## 5 `fc_graphics4mesh.plot` function

The function `fc_graphics4mesh.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

- `'cutPlane'` : (only for simplices in dimension 3) cut mesh by  $n$  planes given by  $n$ -by-4 array  $P$  where the equation of the  $i$ -th cut plane is given by

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

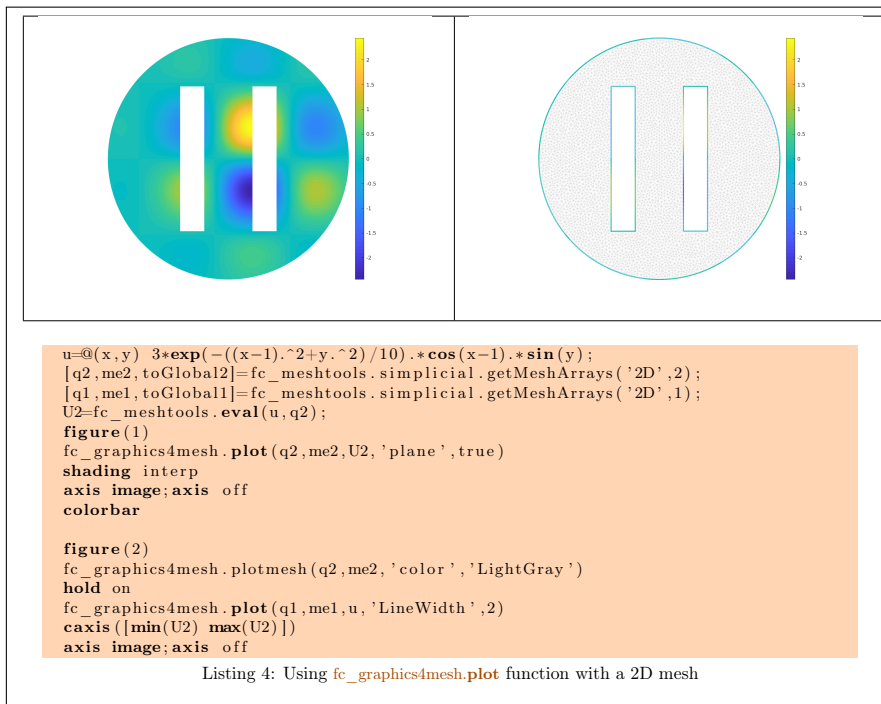
The normal vector  $P(i, 1 : 3)$  pointed to the part of the mesh not displayed. default : `[]` (no cut).

The options of second level depend on the type of elementaries mesh elements to represent.

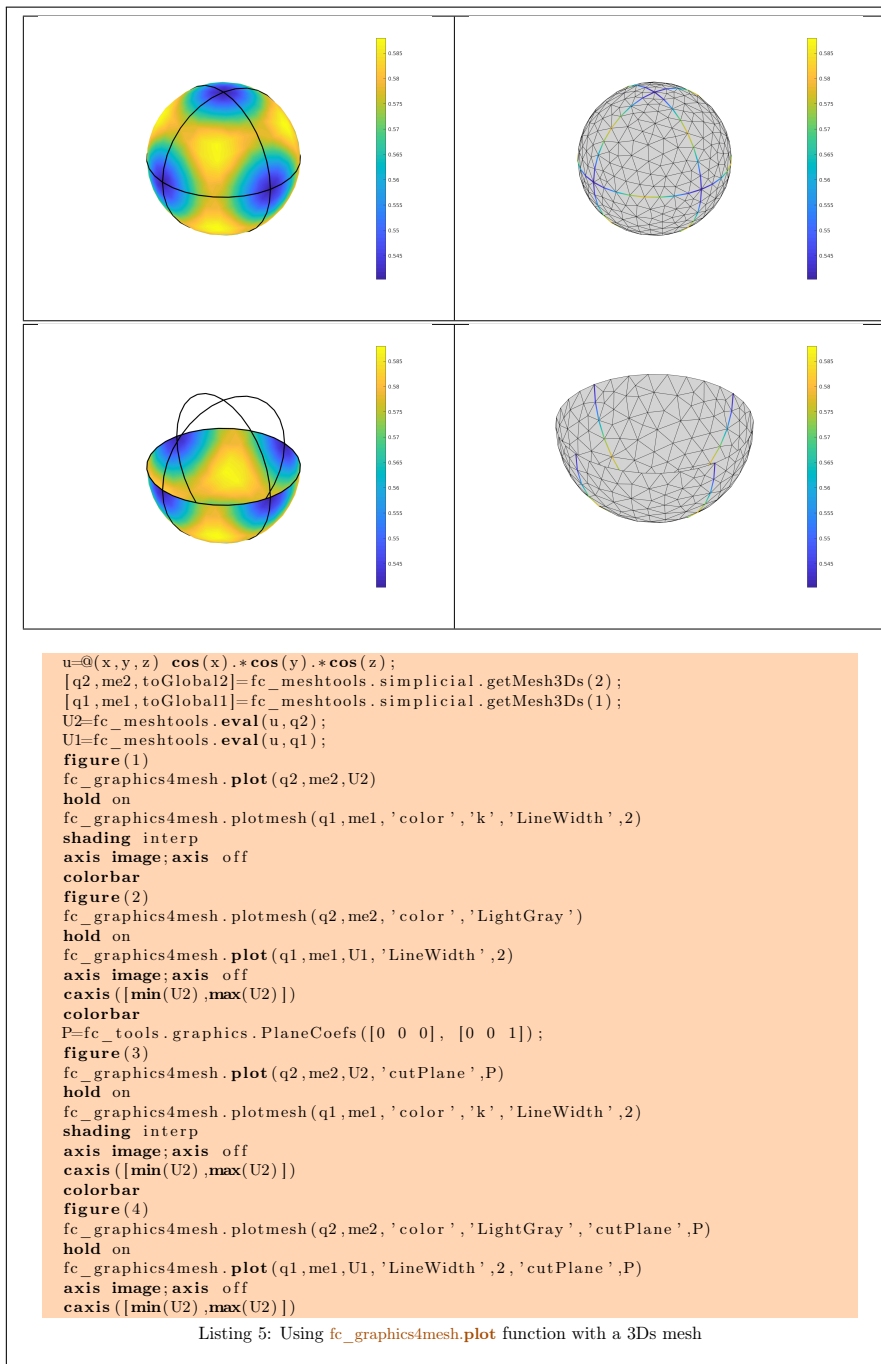
One can use any option of the following functions according to the type of  $d$ -simplex to be represented.

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

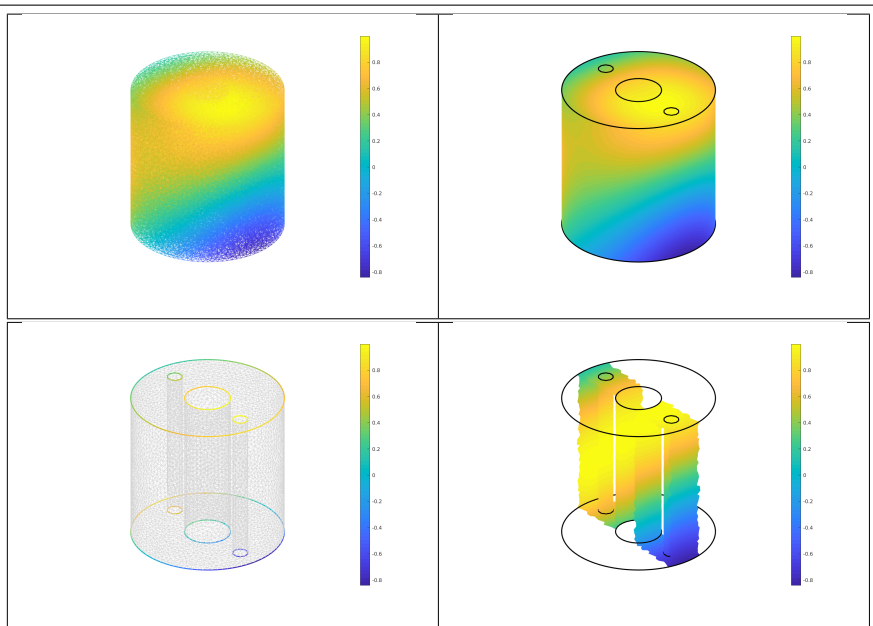
**2D example :** the following code is part of the `fc_graphics4mesh.demos.plot2D` function.



**3Ds example :** the following code is part of the `fc_graphics4mesh.demos.plot3Ds` function.



**3D example :** the following code is part of the `fc_graphics4mesh.demos.plot3D` function.



```

u=@(x,y,z) cos(x).*sin(y+z);
[q3,me3,toGlobal3]=fc_meshtools.simplicial.getMeshArrays('3D',3);
U3=fc_meshtools.eval(u,q3);
[q2,me2,toGlobal2]=fc_meshtools.simplicial.getMeshArrays('3D',2);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.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),'cutPlane',P)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','black','LineWidth',2)
shading interp
axis image;axis off
caxis([min(U3),max(U3)])

```

Listing 6: Using `fc_graphics4mesh.plot` function with a 3D mesh

## 6 `fc_graphics4mesh.plotiso` function

The function `fc_graphics4mesh.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'`)
- `'plane'` : if `true`, isolines are in the  $xy$ -plane, otherwise isolines are in 3D with  $z$ -value set to `u` (default : `false`)
- `'color'` : to specify one color for all isolines (default : empty)
- `'mouse'` : if `true`, display information on clicked isoline (default : `true`)

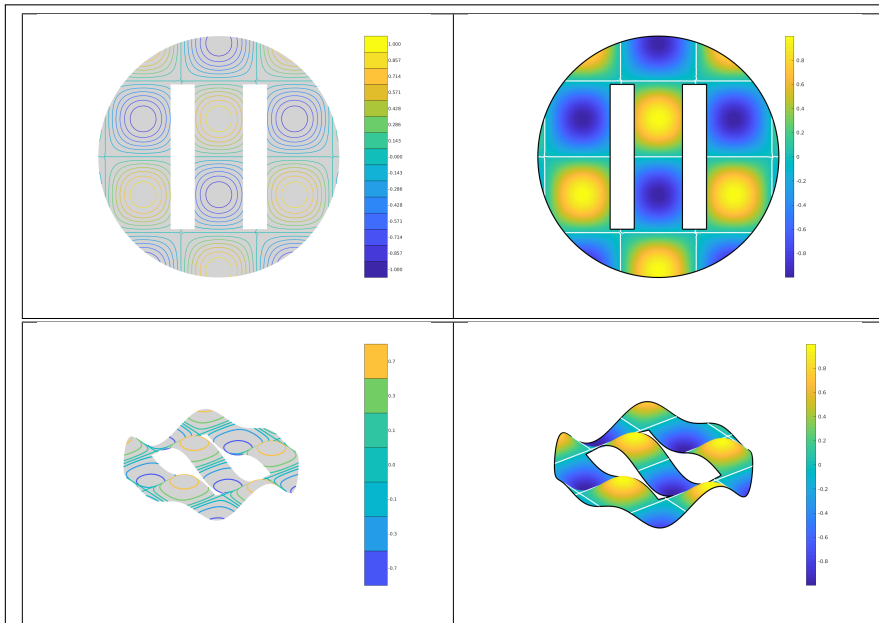
The options of second level are all options of

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

This function accepts until 3 output arguments :

- 1st output is the colors of the isolines
- 2nd output is the isovalues of the isolines
- 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 :** the following code is part of the `fc_graphics4mesh.demos.plotiso2D` function.



```

u=@(x,y) cos(x).*sin(y);
[q2,me2,toGlobal2]=fc_meshtools.simplicial.getMesh2D(2);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.getMesh2D(1);
U2=fc_meshtools.eval(u,q2);
U1=fc_meshtools.eval(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,'plane',true,...
'niso',15,'isocolorbar',true,'format','%3f','LineWidth',1)
axis image;axis off

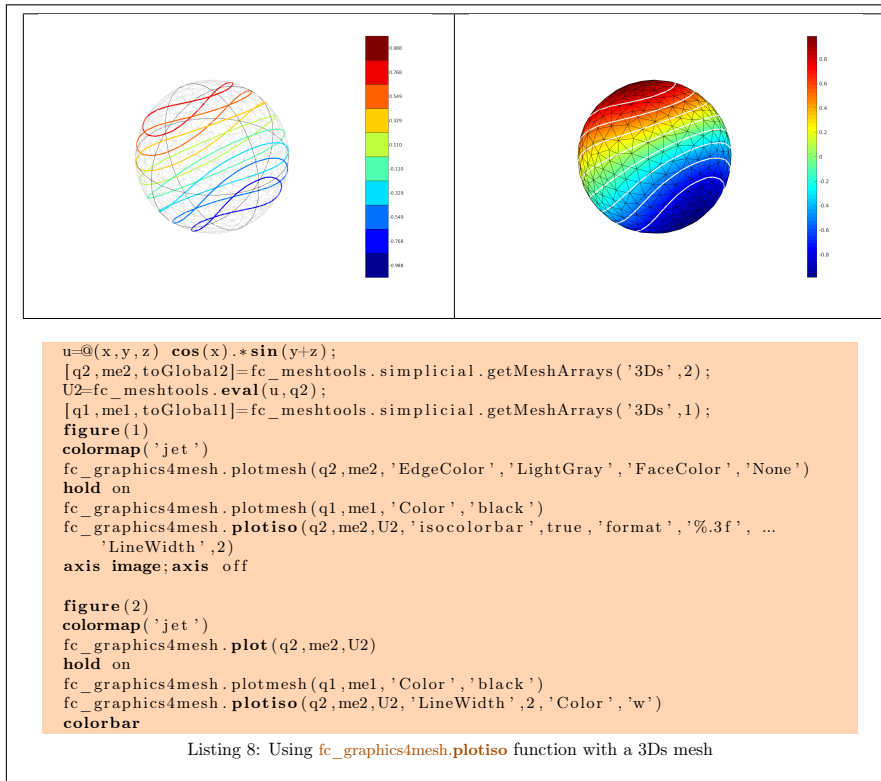
figure(2)
fc_graphics4mesh.plot(q2,me2,U2,'plane',true)
hold on
fc_graphics4mesh.plotiso(q2,me2,U2,'plane',true,...
'Color','w','isorange',0,'LineWidth',2)
fc_graphics4mesh.plotmesh(q1,me1,'LineWidth',2,'Color','k')
colorbar
shading interp
axis image;axis off

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

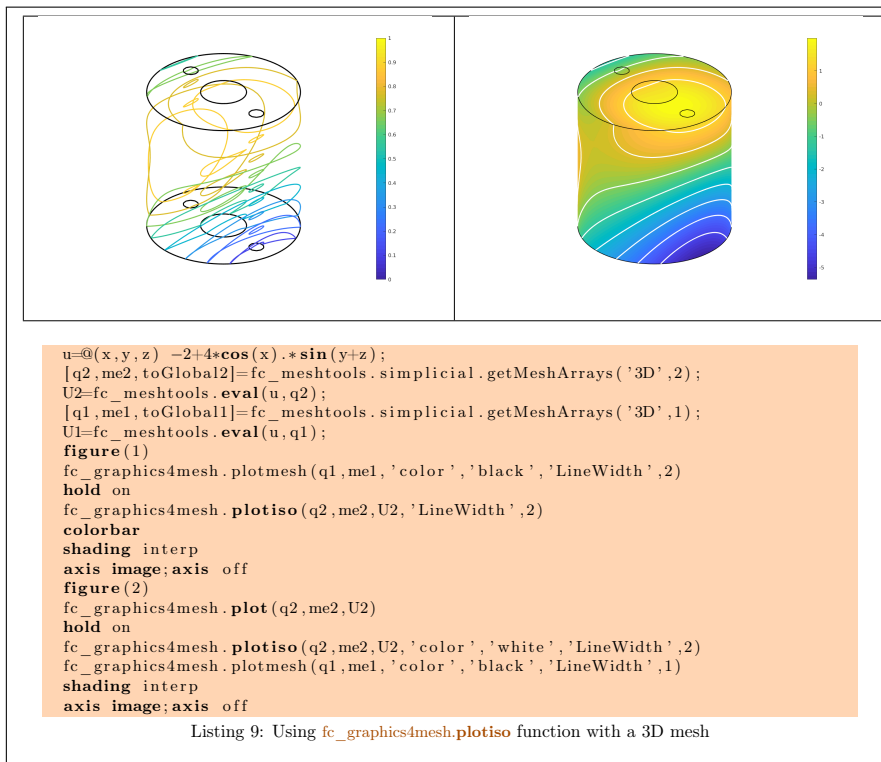
```

Listing 7: Using `fc_graphics4mesh.plotiso` function with a 2D mesh

**3Ds example :** the following code is part of the `fc_graphics4mesh.demos.plotiso3Ds` function.



**3D example :** the following code is part of the `fc_graphics4mesh.demos.plotiso3D` function.



## 7 `fc_graphics4mesh.slicemesh` function

The `fc_graphics4mesh.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  $P = \text{fc\_tools.graphicsPlaneCoefs}(Q,V)$  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.

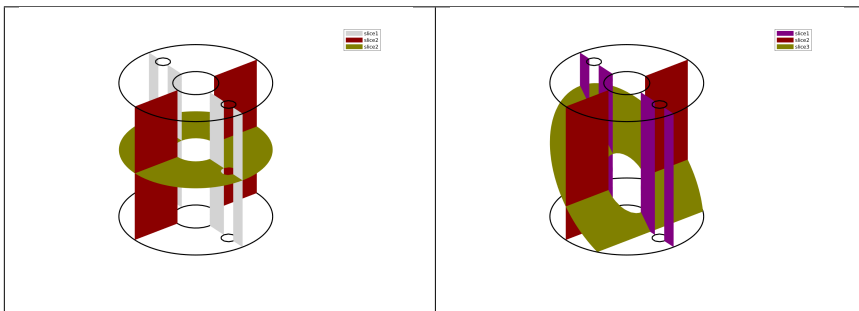
`slicemesh(q,me,P,Name,Value,...)` specifies function options using one or more `Name,Value` pair arguments. Options of first level are



- '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 :** the following code is part of the `fc_graphics4mesh.demos.slicemesh3D` function.



```
[q3,me3,toGlobal3]=fc_meshtools.simplicial.getMeshArrays('3D',3);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.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
```

Listing 10: Using `fc_graphics4mesh.slicemesh` function with a 3D mesh

## 8 `fc_graphics4mesh.slice` function

The `fc_graphics4mesh.slice` function displays intersection of a plane and a 3D mesh given by its vertices array `q` and its connectivity array `me`.

### Syntaxe

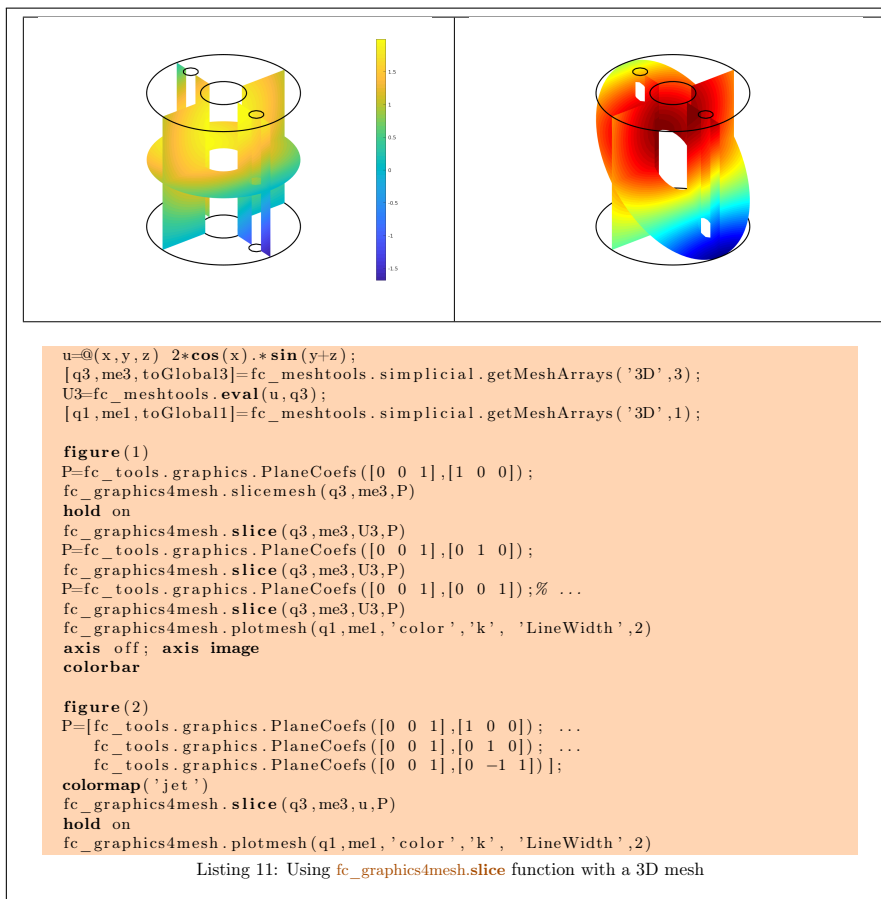
```
fc_graphics4mesh.slice(q,me,u,P)
fc_graphics4mesh.slice(q,me,u,P,Name,Value,...)
```

### 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.graphics.PlaneCoefs(Q,V)` where  $Q$  is a point in the plane and  $V$  is a vector orthogonal to it. One can also use 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 :** the following code is part of the `fc_graphics4mesh.demos.slice3D` function.



## 9 `fc_graphics4mesh.sliceiso` function

The `fc_graphics4mesh.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

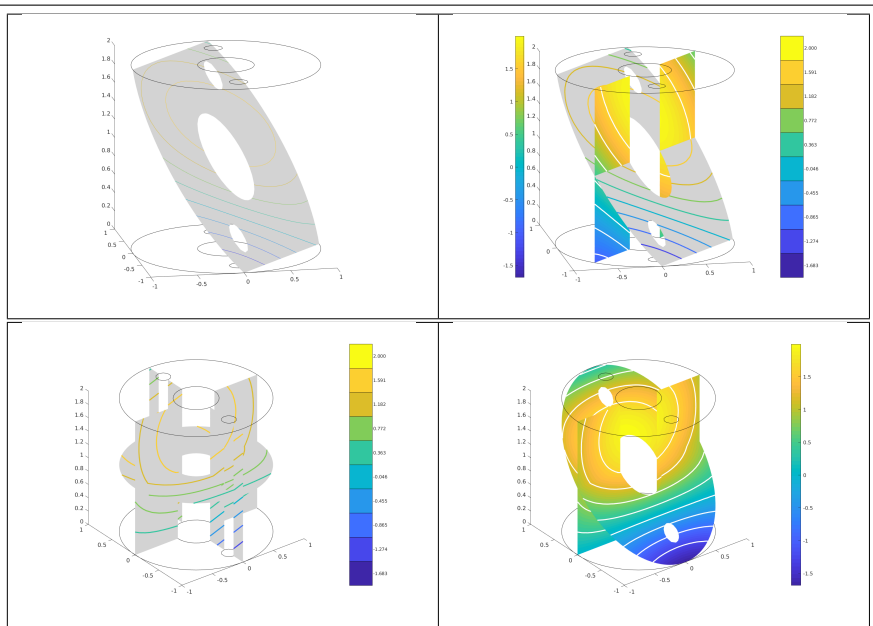
- `'niso'` : to specify the number of isolines (default : 10)
- `'isorange'` : to specify the list of isovalues (default : empty)
- `'color'` : to specify one color for all isolines (default : empty)
- `'isocolorbar'` : if true display a colorbar.Default is false.
- `'format'` : to specify the format 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 :** the following code is part of the `fc_graphics4mesh.demos.sliceiso3D` function.



```

u=@(x,y,z) 2*cos(x).*sin(y+z);
[q3,me3,toGlobal3]=fc_meshtools.simplicial.getMeshArrays('3D',3);
U3=fc_meshtools.eval(u,q3);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.getMeshArrays('3D',1);

```

```

figure(1)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[1 -1 1]);
fc_graphics4mesh.slicemesh(q3,me3,P)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P)
axis equal;axis image
view(-11,15)

```

```

figure(2)
P=fc_tools.graphics.PlaneCoefs([0 0 1],[1 -1 1]);
fc_graphics4mesh.slicemesh(q3,me3,P)
hold on
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'Linewidth',2, ...
    'isocolorbar',true,'LineWidth',2,'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','LineWidth',2);
axis equal;axis image
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
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'isocolorbar',true,'LineWidth',2, ...
    'format','%3f');
axis equal;axis image

```

```

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
fc_graphics4mesh.plotmesh(q1,me1,'color','k')
fc_graphics4mesh.sliceiso(q3,me3,U3,P,'Color','w','LineWidth',2);
caxis([min(U3),max(U3)])
axis equal;axis image

```

Listing 12: Using `fc_graphics4mesh.sliceiso` function with a 3D mesh

## 10 `fc_graphics4mesh.plotquiver` function

The function `fc_graphics4mesh.plotquiver` displays vector field data 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 a 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

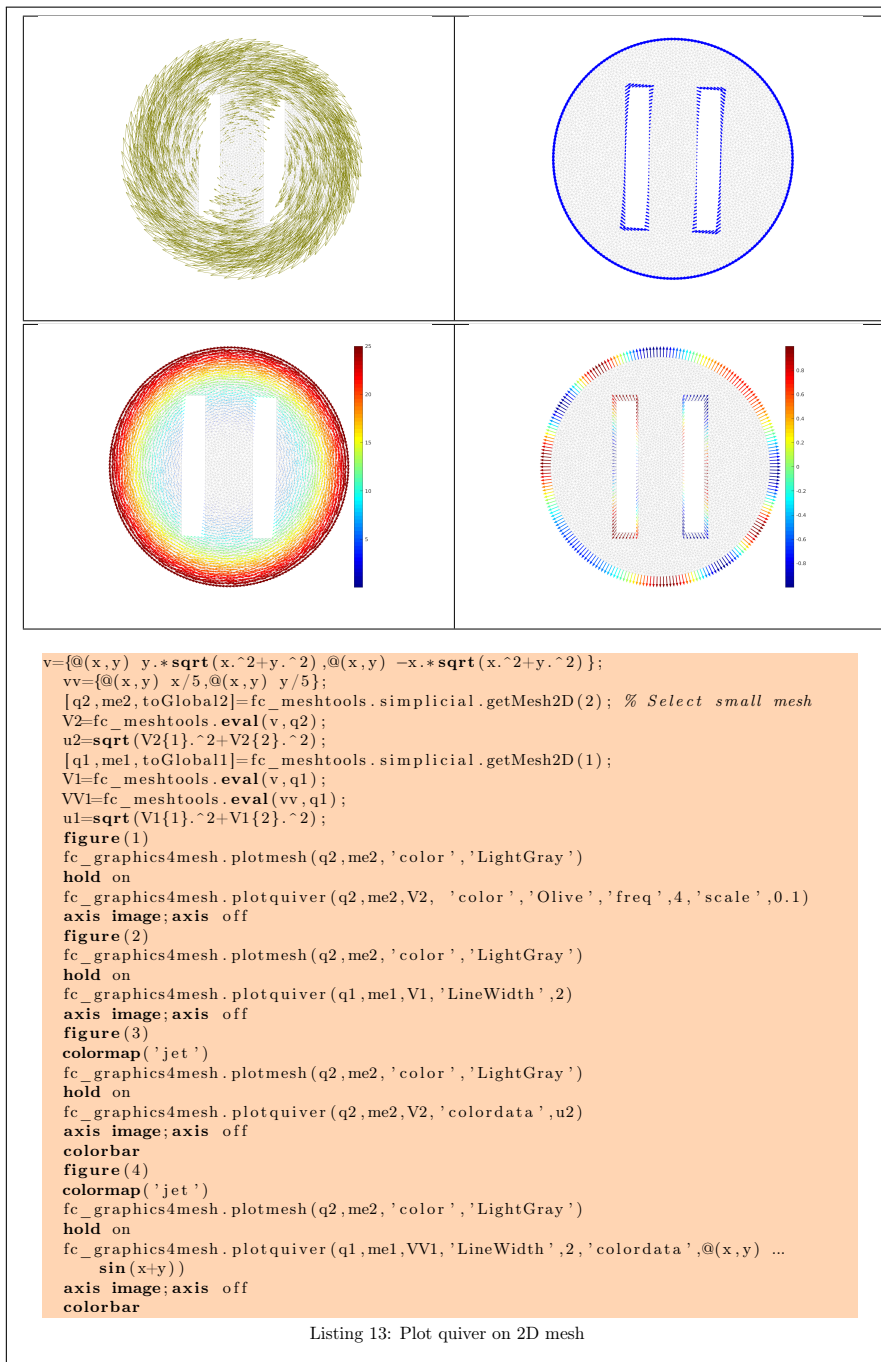
- `'freq'` : quiver frequency, (default : 1)
- `'scale'` : quiver scale, (default is `fc_meshtools.getCharacteristicLength(q)/20`)
- `'color'` : set one color for all quivers (default: default color of the `quiver` or `quiver3` functions). Cannot be used with `'colordata'` option.
- `'colordata'` : each quiver is colored with a 1-by- $n_q$  array or a handle function (it will be 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.

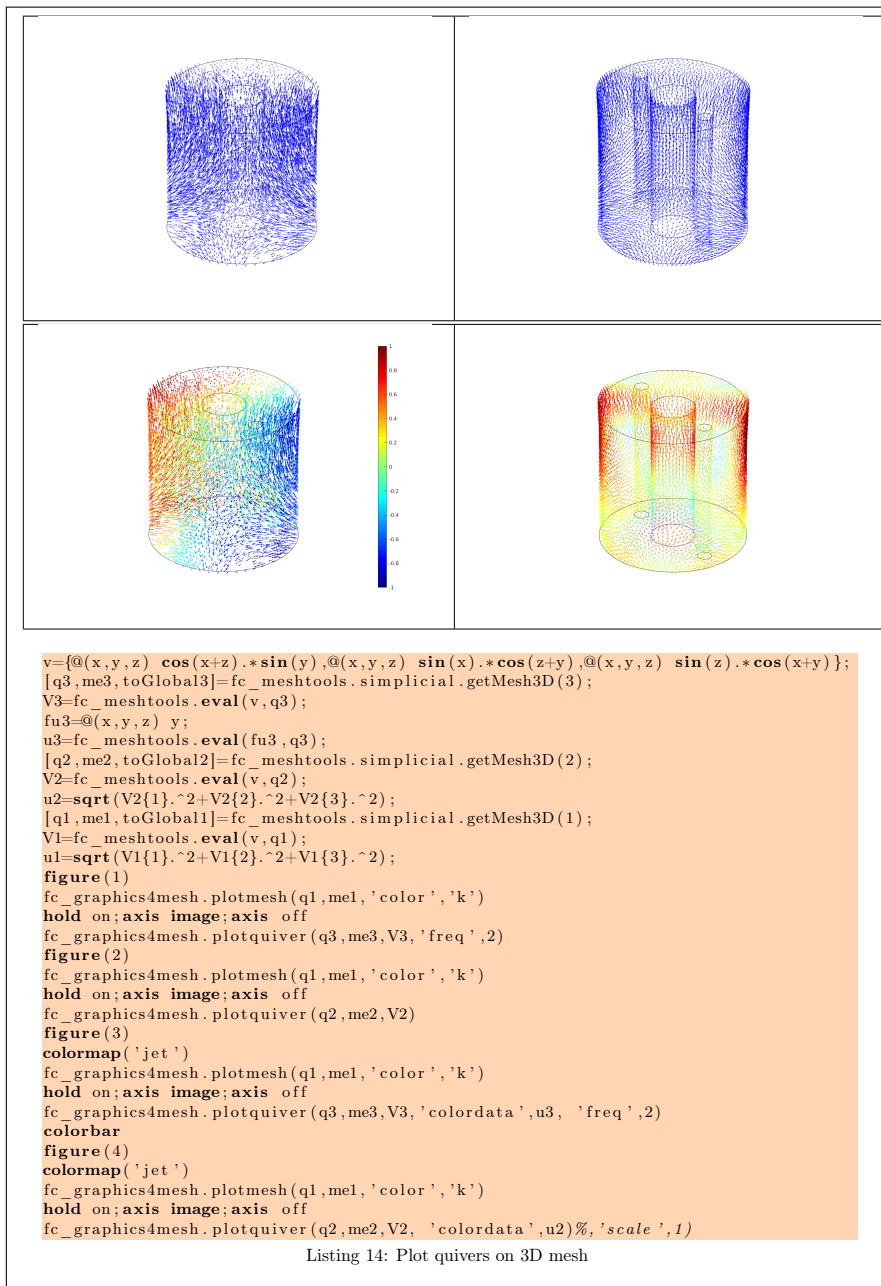
- In dimension 3 and with empty `'colordata'`, the `quiver3` function is used.
- In dimension 2 and with empty `'colordata'`, the `quiver` function is used.
- In dimension 2 or 3 and with no empty `'colordata'`, the third party `fc_tools.graphics.vfield3.vfield3` function is used.

### 2D example

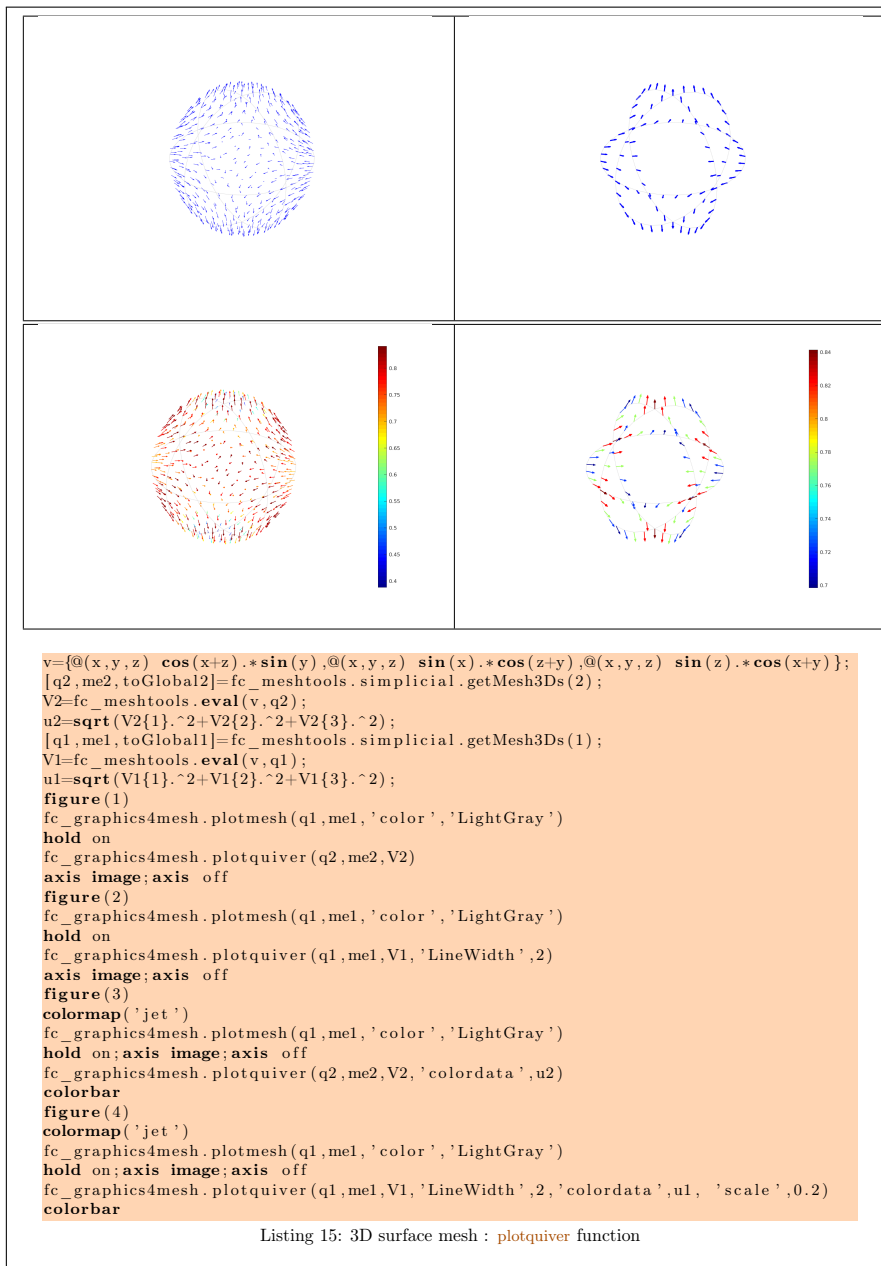


Listing 13: Plot quiver on 2D mesh

### 3D example



### 3D surface example



## 11 fc\_graphics4mesh.plotnodes function

The function `fc_graphics4mesh.plotnodes` displays the nodes of a given mesh nodes array

**Syntaxe**



```
fc_graphics4mesh.plotnodes(q)
fc_graphics4mesh.plotnodes(q,Name,Value, ...)
```

## Description

`plotnodes(q)` displays all the nodes of the array `q` with a specific marker.

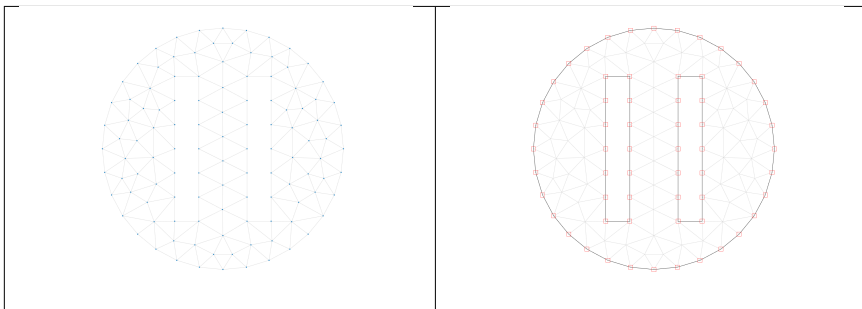
`plotnodes(q,Name,Value, ...)` specifies options using one or more `Name,Value` pair arguments. Options of first level are

- `'Marker'` : to specify the marker (default : `'.'`),
- `'MarkerSize'` : to specify the marker size (default : `6`),
- `'idx'` : to specify indices of the nodes to be displayed,

The options of second level depend on the dimension :

- if dimension 2, then options are those of the `plot` function,
- if dimension 3, then options are those of the `plot3` function.

**2D example :** the following code is part of the `fc_graphics4mesh.demos.plotnodes2D` function.

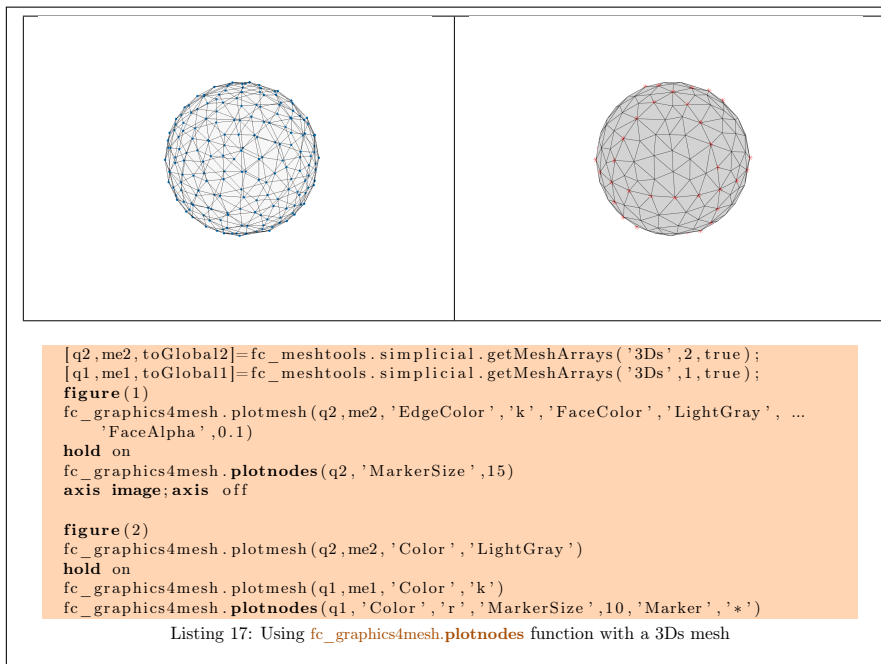


```
[q2,me2,toGlobal2]=fc_meshtools.simplicial.getMeshArrays('2D',2,true);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.getMeshArrays('2D',1,true);
figure(1)
fc_graphics4mesh.plotmesh(q2,me2,'Color','LightGray')
hold on
fc_graphics4mesh.plotnodes(q2)
axis image;axis off

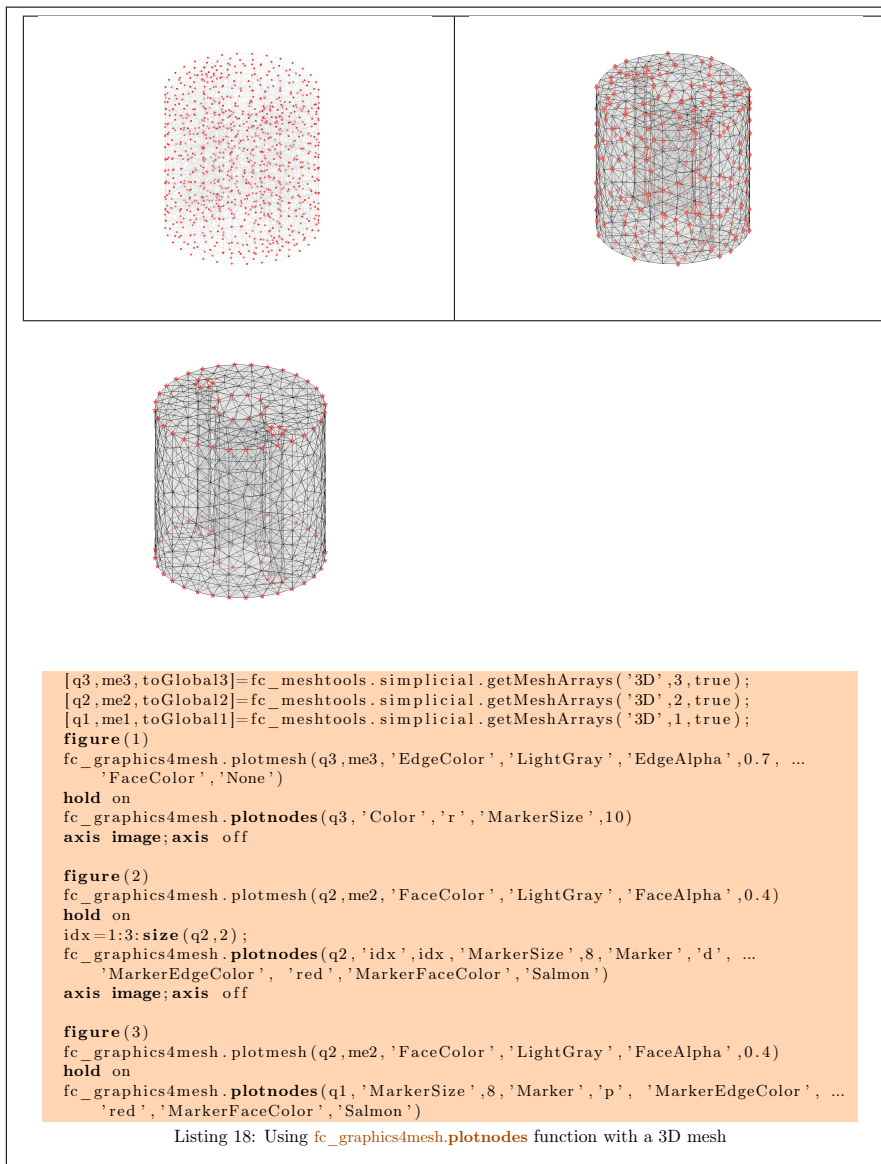
figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'Color','LightGray')
hold on
fc_graphics4mesh.plotmesh(q1,me1,'Color','k')
fc_graphics4mesh.plotnodes(q1,'Color','r','MarkerSize',10,'Marker','s')
```

Listing 16: Using `fc_graphics4mesh.plotnodes` function with a 2D mesh

**3Ds example :** the following code is part of the `fc_graphics4mesh.demos.plotnodes3Ds` function.



**3D example :** the following code is part of the `fc_graphics4mesh.demos.plotnodes3D` function.



## 12 `fc_graphics4mesh.plotnodesidx` function

The function `fc_graphics4mesh.plotnodesidx` displays indices of the given mesh nodes array

### Syntaxe

```

fc_graphics4mesh.plotnodesidx(q,
fc_graphics4mesh.plotnodesidx(q,Name,Value,...)

```

### Description

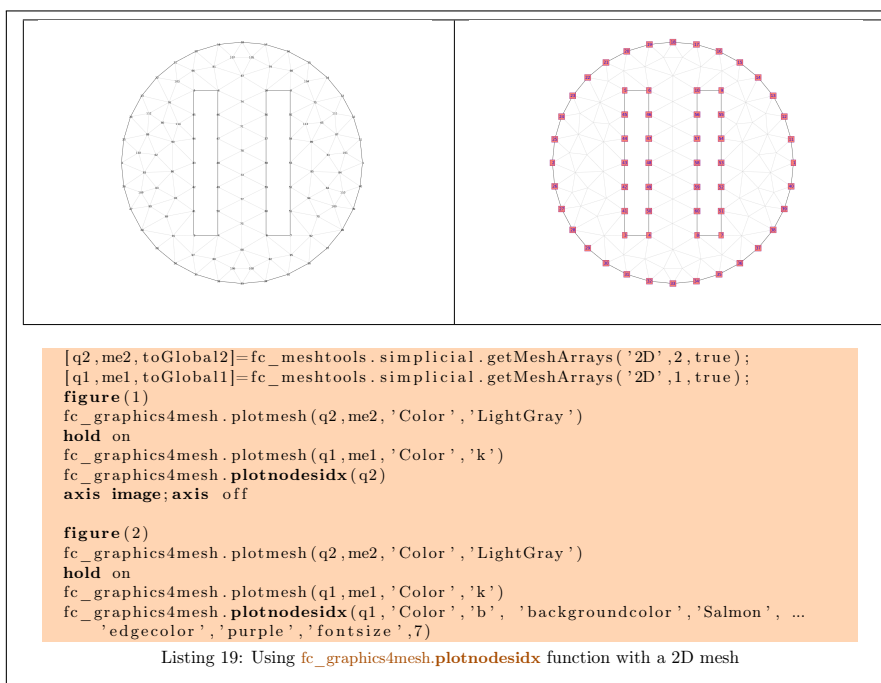
`plotnodesidx(q)` displays all the numbers/indices of the nodes array `q`

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

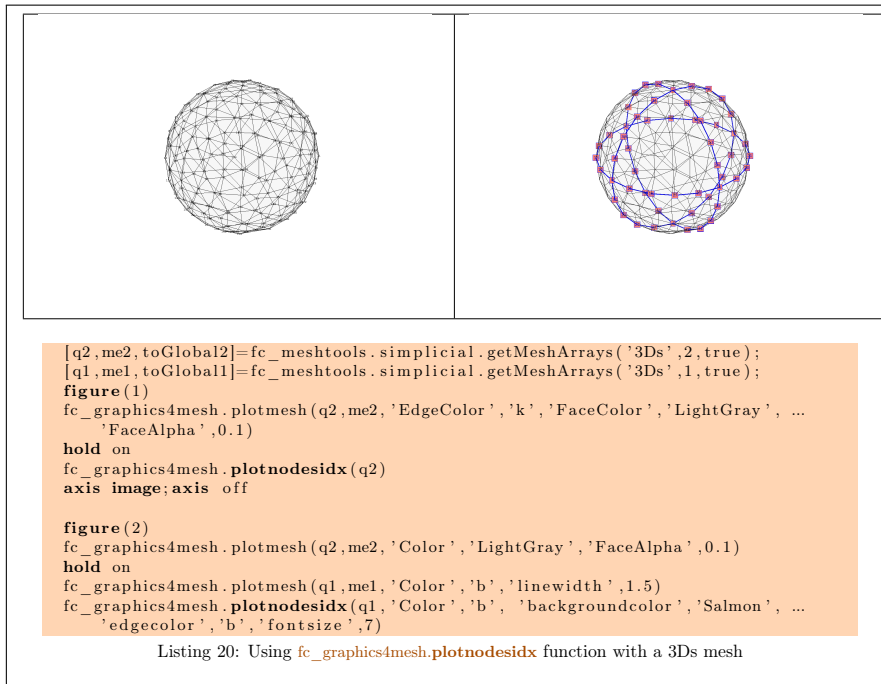
- `'toGlobal'` : to specify other indices to display,
- `'idx'` : to select particular indices.

The options of second level are those of the `text` function.

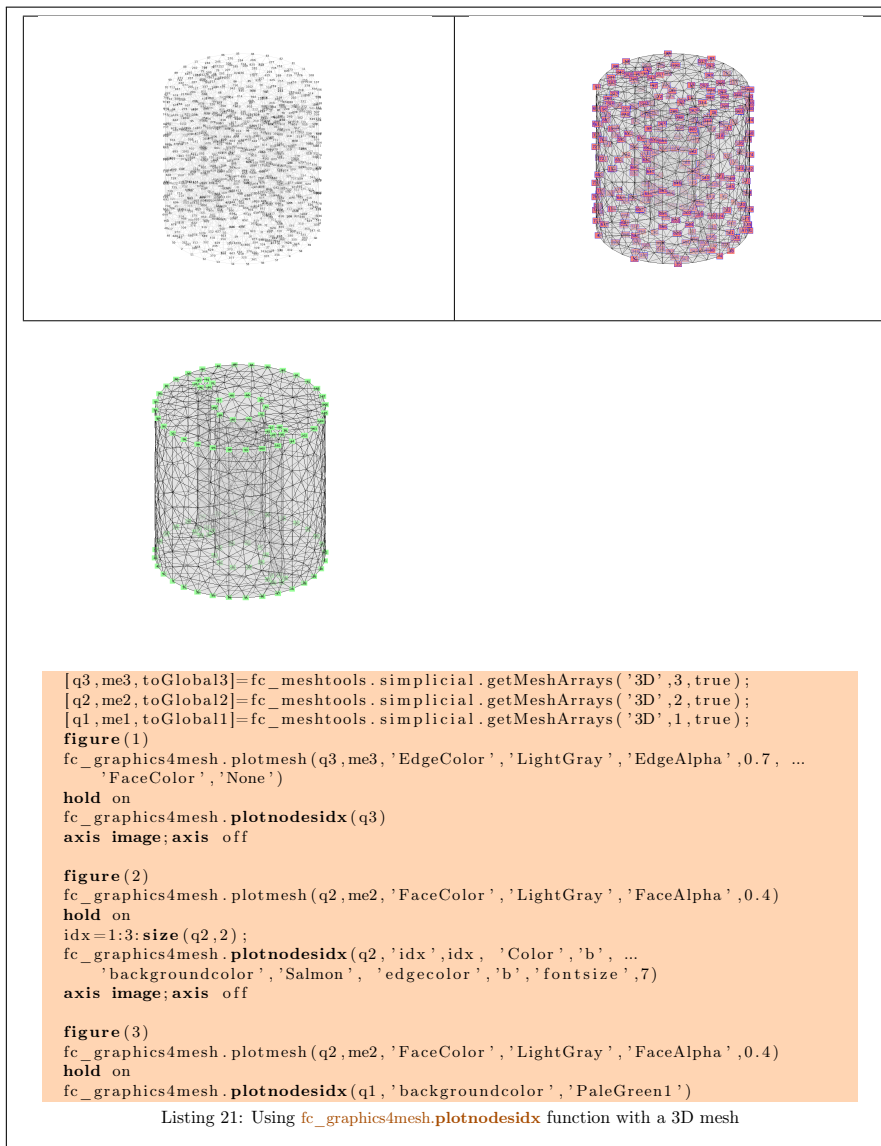
**2D example :** the following code is part of the `fc_graphics4mesh.demos.plotnodesidx2D` function.



**3Ds example :** the following code is part of the `fc_graphics4mesh.demos.plotnodesidx3Ds` function.



**3D example :** the following code is part of the `fc_graphics4mesh.demos.plotnodesidx3D` function.



## 13 `fc_graphics4mesh.plotelementsidx` function

The function `fc_graphics4mesh.plotelementsidx` displays indices of a given mesh connectivity array

### Syntaxe

```

fc_graphics4mesh.plotelementsidx(q,me)
fc_graphics4mesh.plotelementsidx(q,me,Name,Value, ...
... )

```

## Description

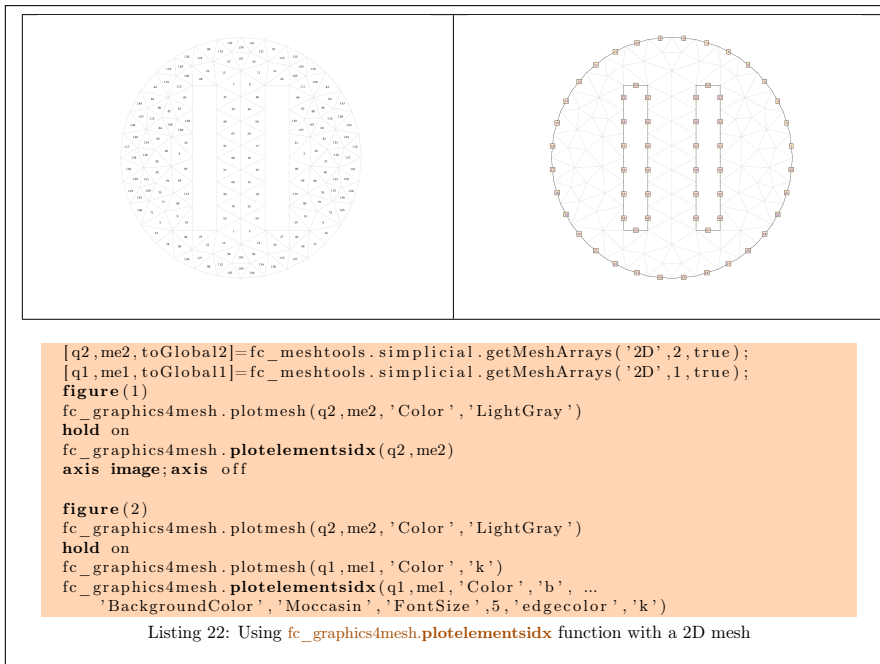
`plotelementsidx(q,me)` displays all the numbers/indices of the connectivity array `me`.

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

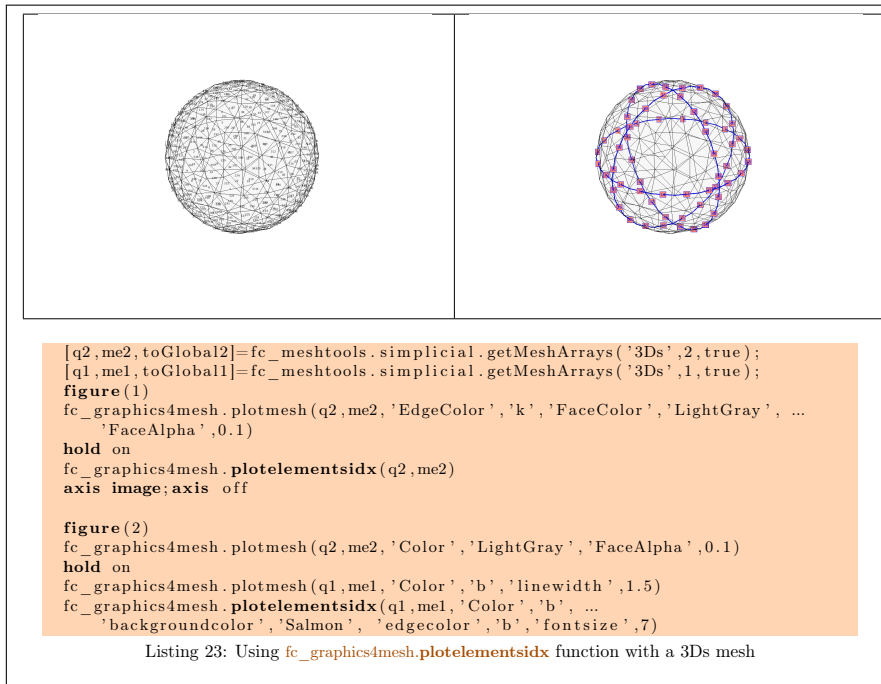
- `'toGlobal'` : to specify other indices to display,
- `'idx'` : to select particular indices.

The options of second level are those of the `text` function.

**2D example :** the following code is part of the `fc_graphics4mesh.demos.plotelementsidx2D` function.

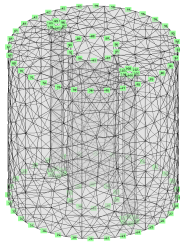
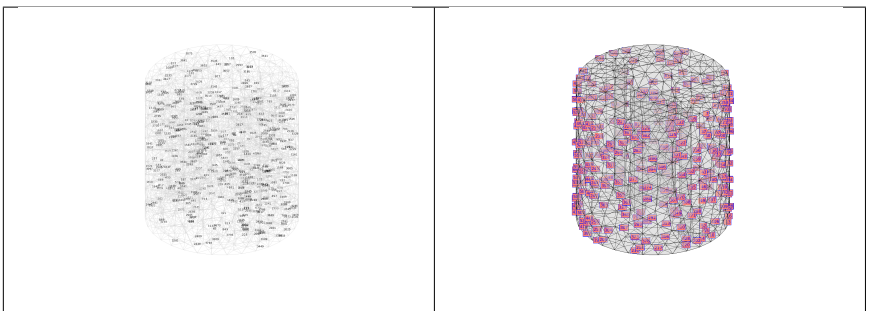


**3Ds example :** the following code is part of the `fc_graphics4mesh.demos.plotelementsidx3Ds` function.



**3D example :** the following code is part of the `fc_graphics4mesh.demos.plotelementsidx3D` function.





```
[q3,me3,toGlobal3]=fc_meshtools.simplicial.getMeshArrays('3D',3,true);
[q2,me2,toGlobal2]=fc_meshtools.simplicial.getMeshArrays('3D',2,true);
[q1,me1,toGlobal1]=fc_meshtools.simplicial.getMeshArrays('3D',1,true);
figure(1)
fc_graphics4mesh.plotmesh(q3,me3,'EdgeColor','LightGray','EdgeAlpha',0.7, ...
    'FaceColor','None')
hold on
idx=1:8;size(me3,2);
fc_graphics4mesh.plotelementsidx(q3,me3,'idx',idx)
axis image;axis off

figure(2)
fc_graphics4mesh.plotmesh(q2,me2,'FaceColor','LightGray','FaceAlpha',0.4)
hold on
idx=1:3;size(q2,2);
fc_graphics4mesh.plotelementsidx(q2,me2,'idx',idx, 'Color','b', ...
    'backgroundcolor','Salmon', 'edgcolor','b','fontsize',7)
axis image;axis off

figure(3)
fc_graphics4mesh.plotmesh(q2,me2,'FaceColor','LightGray','FaceAlpha',0.4)
hold on
fc_graphics4mesh.plotelementsidx(q1,me1,'backgroundcolor','PaleGreen1')
```

Listing 24: Using `fc_graphics4mesh.plotelementsidx` function with a 3D mesh

## Informations for git maintainers of the Matlab toolbox

git informations on the toolboxes used to build this manual

```
-----  
name : fc-graphics4mesh  
tag : 0.1.2  
commit : e922041e090275b69207ed6d4fb52df06f5e3fba  
date : 2020-03-07  
time : 16-09-48  
status : 0  
-----  
name : fc-tools  
tag : 0.0.31  
commit : 3a25f08630ff69e7f8ef4ab451671e454c492e36  
date : 2020-02-23  
time : 11-27-44  
status : 0  
-----  
name : fc-bench  
tag : 0.1.2  
commit : 666dc60d1277f5fa9c99dee4ae1c33270f22c57d  
date : 2020-02-16  
time : 06-38-46  
status : 0  
-----  
name : fc-amat  
tag : 0.1.2  
commit : 957340f6e71d805dbd8b9d04c434b24fd3f92591  
date : 2020-02-16  
time : 06-39-42  
status : 0  
-----  
name : fc-meshtools  
tag : 0.1.3  
commit : cdbc41bc98af4e4faccc1746024aced1f21aae53  
date : 2020-02-17  
time : 10-52-56  
status : 0  
-----
```

git informations on the L<sup>A</sup>T<sub>E</sub>X package used to build this manual

```
-----  
name : fctools  
tag :  
commit : 57968c4a96c2593cccc9da9efd3e52b2ff012cb5  
date : 2020-02-07  
time : 06:41:09  
status : 1  
-----
```

Using the remote configuration repository:

```
url      ssh://lagagit/MCS/Cuvelier/Matlab/fc-config  
commit  5e45f254c19250ff5077a8477825e6c975245689
```