FC_OOGMSH package, User's Guide *

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May 10, 2017

Abstract

This Python package make it possible to generate mesh files from *.geo* file by using `gmsh`. It's also possible with the ooGmsh class to read the mesh file and to store its contains in more user-friendly form. This package must be regarded as a very simple interface between gmsh files and Python. So you are free to create any data structures or objects you want from an ooGmsh object.

Contents

*Compiled with Python 3.6.0, packages fc_oogmsh-0.0.4 and `fc_tools`-0.0.10

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This work was partially supported by ANR Dedales.

1 Introduction

The FC_OOGMSH Python package is closely related to `gmsh`, see [2] or [1], which is a three-dimensional finite element mesh generator with built-in pre- and post-processing facilities. `gmsh` can also build two-dimensional meshes and three-dimensional surface meshes. This package was initialy created to make it possible from Python to rapidly

- generate mesh file from .geo file by using `gmsh`
- efficiently read this mesh file and store its contents in OOGMSH Python object easy to manipulate.

The OOGMSH Python object can be used to create, from a .msh file, any data structures or objects needed by your project. For example, the fc-simesh Python package uses this package to create the SIMESH object containing all the simplices elements of the mesh.

In a first step we quickly present the installation of `gmsh` on Linux (for Windows and Mac OS X precompiled software are also provided on `http://gmsh.info`). Then, we explain how to configure the FC_OOGMSH packagefor using `gmsh`. Finaly, we describe the FC_OOGMSH's functions which use `gmsh` to create mesh files.

remark 1.1

Under Windows the 32bit version of gmsh is needed : the system function of Python seems not to support running 64bit applications.

2 gmsh installation (Linux 64bit)

Binaries for Linux 64 bits are availabled on `http://gmsh.info`).

- To obtain the current stable release (version 2.15.0, December 4 2016) directly from a terminal one can run

```
Terminal
wget http://gmsh.info/bin/Linux/gmsh-2.15.0-
    Linux64.tgz
```

- To obtain the development version (automated nightly snapshots) directly from a terminal one can run

```
Terminal
wget http://gmsh.info/bin/Linux/gmsh-svn-Linux64.tgz
```

To install the version 2.15.0 on directory `~/software/GMSH`, one can do the commands

```
Terminal
mkdir -p ~/software/GMSH
cd ~/software/GMSH
wget http://gmsh.info/bin/Linux/gmsh-2.15.0-Linux64.tgz
tar zxvf gmsh-2.15.0-Linux64.tgz
```

To run `gmsh` we can used the following command in a terminal

```
Terminal
~/software/GMSH/gmsh-2.15.0-Linux/bin/gmsh &
```

3 gmsh interface

All the functions provided in this section use `gmsh` to create a mesh file from a `gmsh` geometry script file (extension *.geo*).

3.1 function gmsh.buildmesh2d

This function uses `gmsh` and a *.geo* file (describing a 2D-geometry) to generate a 2D-mesh.

Syntaxe

```
meshfile=gmsh.buildmesh2d(geofile,N)

meshfile=gmsh.buildmesh2d(geofile,N,Key=Value)
```

Description

meshfile=gmsh.buildmesh2d(geofile,N) create a 2D-mesh using `gmsh` and the *geo* file geofile (without path). The integer N has two functions : numbering the name of the generated mesh as <geofile without extension and path> + <-N.msh> and passing this number to `gmsh` via the option "-setnumber N <N>". Usually we used this parameter in `gmsh` to set the prescribed mesh element size at the points. (see given *geo* files)
As output return a file name (with full path) corresponding to the mesh generated by `gmsh`.

meshfile=gmsh.buildmesh2d(geofile,N,Key=Value, ...) specifies function options using one or more Key,Value pair arguments. The Key options can be

- `meshdir` : to specify the directory where the mesh file will be written, (default : false)
- `force` : to force meshing even if the mesh file already exists if Value is true (default : false)
- `verbose` : to specify the degree of verbosity (0, silence; 2, default; ...)
- `options` : string which contains command-line options used with gmsh (see `gmsh` documentation)

Examples All the following examples use the *.geo* file `condenser11.geo` which is in the directory `geodir` of the toolbox.

Python commands with output

```
print('*** gmsh.buildmesh2d : 1st call')
meshfile=gmsh.buildmesh2d('condenser11',25,force=True)
print('*** gmsh.buildmesh2d : 2nd call')
meshfile=gmsh.buildmesh2d('condenser11',25)
```

```
*** gmsh.buildmesh2d : 1st call
 Overwritting mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -setnumber N 25
       /fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/condenser11.geo -o
       /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh' [Gmsh 2.16.0, 1 node, max. 1 thread]
Info    : Started on Wed May 10 07:11:56 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/condenser11.geo'...
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/options01_data.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/options01_data.geo'
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/shape_functions.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/shape_functions.geo'
Info    : Removing duplicate mesh vertices...
Info    : Found 0 duplicate vertices
Info    : No duplicate vertices found
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/condenser11.geo'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Meshing curve 101 (Line)
Info    : Meshing curve 102 (Line)
Info    : Meshing curve 103 (Line)
Info    : Meshing curve 104 (Line)
Info    : Meshing curve 106 (Circle)
Info    : Meshing curve 107 (Circle)
Info    : Meshing curve 108 (Circle)
Info    : Meshing curve 109 (Circle)
Info    : Meshing curve 111 (Circle)
Info    : Meshing curve 112 (Circle)
Info    : Meshing curve 113 (Circle)
Info    : Meshing curve 114 (Circle)
Info    : Meshing curve 116 (Circle)
Info    : Meshing curve 117 (Circle)
Info    : Meshing curve 118 (Circle)
Info    : Meshing curve 119 (Circle)
Info    : Meshing curve 121 (Circle)
Info    : Meshing curve 122 (Circle)
Info    : Meshing curve 123 (Circle)
Info    : Meshing curve 124 (Circle)
Info    : Meshing curve 126 (Circle)
Info    : Meshing curve 127 (Circle)
Info    : Meshing curve 128 (Circle)
Info    : Meshing curve 129 (Circle)
Info    : Meshing curve 131 (Circle)
Info    : Meshing curve 132 (Circle)
Info    : Meshing curve 133 (Circle)
Info    : Meshing curve 134 (Circle)
Info    : Meshing curve 136 (Circle)
Info    : Meshing curve 137 (Circle)
Info    : Meshing curve 138 (Circle)
Info    : Meshing curve 139 (Circle)
Info    : Meshing curve 141 (Circle)
Info    : Meshing curve 142 (Circle)
Info    : Meshing curve 143 (Circle)
Info    : Meshing curve 144 (Circle)
Info    : Meshing curve 146 (Circle)
Info    : Meshing curve 147 (Circle)
Info    : Meshing curve 148 (Circle)
Info    : Meshing curve 149 (Circle)
Info    : Done meshing 1D (0.007811 s)
Info    : Meshing 2D...
Info    : Meshing surface 105 (Plane, Delaunay)
Info    : Meshing surface 110 (Plane, Delaunay)
Info    : Meshing surface 120 (Plane, Delaunay)
Info    : Meshing surface 130 (Plane, Delaunay)
Info    : Meshing surface 140 (Plane, Delaunay)
Info    : Meshing surface 150 (Plane, Delaunay)
Info    : Done meshing 2D (0.144384 s)
Info    : 3483 vertices 7099 elements
Info    : Writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'...
Info    : Done writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'
Info    : Stopped on Wed May 10 07:11:56 2017
  -> done!
*** gmsh.buildmesh2d : 2nd call
 Mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh already exist.
  -> Use "force" flag to rebuild if needed.
```

Python commands with output

```
meshfile=gmsh.buildmesh2d('condenser11',25,force=True,
    verbose=True, options='-string "Mesh.Algorithm=1;" -string "Mesh.ScalingFactor=2;"')
```

```
 Overwritting mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -setnumber N 25 -string Mesh.Algorithm=1; -string Mesh.ScalingFactor=2;
       /fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/condenser11.geo -o
       /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh' [Gmsh 2.16.0, 1 node, max. 1 thread]
Info    : Started on Wed May 10 07:11:56 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/condenser11.geo'...
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/options01_data.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/options01_data.geo'
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/shape_functions.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/shape_functions.geo'
Info    : Removing duplicate mesh vertices...
Info    : Found 0 duplicate vertices
Info    : No duplicate vertices found
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/condenser11.geo'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Meshing curve 101 (Line)
Info    : Meshing curve 102 (Line)
Info    : Meshing curve 103 (Line)
Info    : Meshing curve 104 (Line)
Info    : Meshing curve 106 (Circle)
Info    : Meshing curve 107 (Circle)
Info    : Meshing curve 108 (Circle)
Info    : Meshing curve 109 (Circle)
Info    : Meshing curve 111 (Circle)
Info    : Meshing curve 112 (Circle)
Info    : Meshing curve 113 (Circle)
Info    : Meshing curve 114 (Circle)
Info    : Meshing curve 116 (Circle)
Info    : Meshing curve 117 (Circle)
Info    : Meshing curve 118 (Circle)
Info    : Meshing curve 119 (Circle)
Info    : Meshing curve 121 (Circle)
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Info    : Meshing curve 127 (Circle)
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Info    : Meshing curve 139 (Circle)
Info    : Meshing curve 141 (Circle)
Info    : Meshing curve 142 (Circle)
Info    : Meshing curve 143 (Circle)
Info    : Meshing curve 144 (Circle)
Info    : Meshing curve 146 (Circle)
Info    : Meshing curve 147 (Circle)
Info    : Meshing curve 148 (Circle)
Info    : Meshing curve 149 (Circle)
Info    : Done meshing 1D (0.007881 s)
Info    : Meshing 2D...
Info    : Meshing surface 105 (Plane, MeshAdapt)
Info    : Meshing surface 110 (Plane, MeshAdapt)
Info    : Meshing surface 120 (Plane, MeshAdapt)
Info    : Meshing surface 130 (Plane, MeshAdapt)
Info    : Meshing surface 140 (Plane, MeshAdapt)
Info    : Meshing surface 150 (Plane, MeshAdapt)
Info    : Done meshing 2D (0.361494 s)
Info    : 2999 vertices 6131 elements
Info    : Writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'...
Info    : Done writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'
Info    : Stopped on Wed May 10 07:11:57 2017
  -> done!
```

3.2 function gmsh.buildmesh3d

This function uses `gmsh` and a *.geo* file (describing a 3D-geometry) to generate a 3D-mesh. See function `gmsh.buildmesh2d` for usage and options.

3.3 function gmsh.buildmesh3ds

This function uses `gmsh` and a *.geo* file (describing a 3D surface geometry or a 3D-geometry) to generate a 3D surface mesh. See function `gmsh.buildmesh2d` for usage and options.

3.4 function gmsh.buildpartmesh2d

This function uses `gmsh` and a *.msh* file (containing of a 2D-mesh) to generate a 2D partioned mesh.

Syntaxe

```
partmeshfile=gmsh.buildpartmesh2d(meshfile,np)

partmeshfile=gmsh.buildpartmesh2d(meshfile,np,Key=Value)
```

Description

partmeshfile=gmsh.buildpartmesh2d(meshfile,np) create a 2D partitioned mesh using `gmsh` and the *msh* file meshfile (with path). The integer np is the number of partitions.
As output return a file name (with full path) corresponding to the partitioned mesh generated by `gmsh`. The output file name is construct as following : <meshfile without extension>-part<np>.msh

partmeshfile=gmsh.buildpartmesh2d(meshfile,np,Key=Value, ...) specifies function options using one or more Key,Value pair arguments. The Name options can be

- `'force'` : to force meshing even if the mesh file already exists if Value is true (default : false)
- `'verbose'` : to specify the degree of verbosity (0, silence; 2, default; ...)
- `options` : string which contains command-line options used with gmsh (see `gmsh` documentation)

Examples All the following examples use the `meshfile` as output of the command :
meshfile=gmsh.buildmesh2d('condenser11',25);

Python commands with output

```
print('*** Building the mesh')
meshfile=gmsh.buildmesh2d('condenser11',25);
print('*** Partitioning the mesh')
pmfile=gmsh.buildpartmesh(meshfile,5,force=True);
```

```
*** Building the mesh
 Mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh already exist.
  -> Use "force" flag to rebuild if needed.
*** Partitioning the mesh
 Overwritting mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -saveall -part 5
        /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh -o
        /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh' [Gmsh 2.16.0, 1 node, max. 1
        thread]
Info    : Started on Wed May 10 07:11:57 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'...
Info    : 2990 vertices
Info    : 6082 elements
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Done meshing 1D (2.1e-05 s)
Info    : Meshing 2D...
Info    : Done meshing 2D (2.00272e-05 s)
Info    : 2990 vertices 6082 elements
Info    : Building graph...
Info    : Partitioning graph...
Info    : Launching METIS graph partitioner
Info    : Number of Edges Cut : 141
Info    : Done partitioning graph
Info    : Writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh'...
Info    : Done writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh'
Info    : Stopped on Wed May 10 07:11:57 2017
  -> done!
```

Python commands with output

```
print('*** Building the mesh')
meshfile=gmsh.buildmesh2d('condenser11',25, verbose=True);
print('*** Partitioning the mesh')
pmfile=gmsh.buildpartmesh(meshfile,5,force=True,
     verbose=True, options='-string "Mesh.Partitioner=2;" '
     '-string "Mesh.MetisAlgorithm=3;"')
```

```
*** Building the mesh
 Mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh already exist.
  -> Use "force" flag to rebuild if needed.
*** Partitioning the mesh
 Overwritting mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -saveall -part 5 -string Mesh.Partitioner=2; -string Mesh.MetisAlgorithm=3;
        /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh -o
        /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh' [Gmsh 2.16.0, 1 node, max. 1
        thread]
Info    : Started on Wed May 10 07:11:57 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'...
Info    : 2990 vertices
Info    : 6082 elements
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25.msh'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Done meshing 1D (2.6e-05 s)
Info    : Meshing 2D...
Info    : Done meshing 2D (2.00272e-05 s)
Info    : 2990 vertices 6082 elements
Info    : Building graph...
Info    : Partitioning graph...
Info    : Launching METIS graph partitioner
METIS with weights
Info    : Number of Edges Cut : 133
Info    : Done partitioning graph
Info    : Writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh'...
Info    : Done writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser11-25-part5.msh'
Info    : Stopped on Wed May 10 07:11:57 2017
  -> done!
```

3.5 function gmsh.buildpartmesh3d

This function uses `gmsh` and a *.msh* file (containing of a 3D-mesh) to generate a 3D partioned mesh.

3.6 function gmsh.buildpartmesh3ds

This function uses `gmsh` and a *.msh* file (containing of a 3D surface mesh) to generate a 3D partioned surface mesh.

3.7 function gmsh.buildPartRectangle

This function uses `gmsh` and the *geodir/rectanglepart.geo* file to generate a 2D regular partioned mesh of the rectangle $[0, Lx] \times [0, Ly]$ with $Nx \times Ny$ partitions.

Syntaxe

```
meshfile=gmsh.buildpartrectangle(Lx,Ly,Nx,Ny,N)

meshfile=gmsh.buildpartrectangle(Lx,Ly,Nx,Ny,N,
    Key=Value)
```

Description

`meshfile=gmsh.buildpartrectangle(Lx,Ly,Nx,Ny,N)` create a 2D regular partitioned mesh using `gmsh` of the rectangle $[0, Lx] \times [0, Ly]$ with $Nx \times Ny$ partitions. The N parameter is passed to `gmsh` to set the prescribed mesh element size at the points
As output return a file name (with full path) corresponding to the partitioned mesh generated by `gmsh`. The default output file name is construct as following : rectanglepart-Lx%.3f-Ly%.3f-Nx%d-Ny%d-N%d.msh

`meshfile=gmsh.buildpartrectangle(Lx,Ly,Nx,Ny,N,Key=Value, ...)` specifies function options using one or more Key,Value pair arguments. The Key options can be

- `'force'` : to force meshing even if the mesh file already exists if Value is true (default : false)
- `'verbose'` : to specify the degree of verbosity (0, silence; 2, default; ...)
- `options` : string which contains command-line options used with gmsh (see `gmsh` documentation)

Examples All the following examples ...

Python commands with output

```
pmfile=gmsh.buildpartrectangle(1,1,3,2,100,force=True,
    verbose=True)
```

```
 Overwritting mesh file rectanglepart-Lx1.000-Ly1.000-Nx3-Ny2-N100.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -setnumber N 100 -setnumber NX 3 -setnumber NY 2 -setnumber LX 1 -setnumber
      LY 1 /fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/rectanglepart.geo -o
      rectanglepart-Lx1.000-Ly1.000-Nx3-Ny2-N100.msh' [Gmsh 2.16.0, 1 node, max. 1 thread]
Info    : Started on Wed May 10 07:11:58 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/rectanglepart.geo'...
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions01_data.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions01_data.geo'
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions_shape.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions_shape.geo'
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/rectanglepart.geo'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Meshing curve 1 (Line)
Info    : Meshing curve 2 (Line)
Info    : Meshing curve 3 (Line)
Info    : Meshing curve 4 (Line)
Info    : Meshing curve 5 (Line)
Info    : Meshing curve 6 (Line)
Info    : Meshing curve 7 (Line)
Info    : Meshing curve 8 (Line)
Info    : Meshing curve 9 (Line)
Info    : Meshing curve 10 (Line)
Info    : Meshing curve 11 (Line)
Info    : Meshing curve 12 (Line)
Info    : Meshing curve 13 (Line)
Info    : Meshing curve 14 (Line)
Info    : Meshing curve 15 (Line)
Info    : Meshing curve 16 (Line)
Info    : Meshing curve 17 (Line)
Info    : Done meshing 1D (0.003465 s)
Info    : Meshing 2D...
Info    : Meshing surface 19 (Plane, Delaunay)
Info    : Meshing surface 21 (Plane, Delaunay)
Info    : Meshing surface 23 (Plane, Delaunay)
Info    : Meshing surface 25 (Plane, Delaunay)
Info    : Meshing surface 27 (Plane, Delaunay)
Info    : Meshing surface 29 (Plane, Delaunay)
Info    : Done meshing 2D (0.472 s)
Info    : 13685 vertices 27682 elements
Info    : Writing 'rectanglepart-Lx1.000-Ly1.000-Nx3-Ny2-N100.msh'...
Info    : Done writing 'rectanglepart-Lx1.000-Ly1.000-Nx3-Ny2-N100.msh'
Info    : Stopped on Wed May 10 07:11:58 2017
  -> done!
```

Python commands with output

```
pmfile=gmsh.buildpartrectangle(1,1,3,2,100,verbose=True,
    force=True,meshfile='./toto.msh')
```

```
 Overwritting mesh file ./toto.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -setnumber N 100 -setnumber NX 3 -setnumber NY 2 -setnumber LX 1 -setnumber
      LY 1 /fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/rectanglepart.geo -o ./toto.msh' [Gmsh
      2.16.0, 1 node, max. 1 thread]
Info    : Started on Wed May 10 07:11:58 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/rectanglepart.geo'...
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions01_data.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions01_data.geo'
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions_shape.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/partitions_shape.geo'
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/2d/rectanglepart.geo'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Meshing curve 1 (Line)
Info    : Meshing curve 2 (Line)
Info    : Meshing curve 3 (Line)
Info    : Meshing curve 4 (Line)
Info    : Meshing curve 5 (Line)
Info    : Meshing curve 6 (Line)
Info    : Meshing curve 7 (Line)
Info    : Meshing curve 8 (Line)
Info    : Meshing curve 9 (Line)
Info    : Meshing curve 10 (Line)
Info    : Meshing curve 11 (Line)
Info    : Meshing curve 12 (Line)
Info    : Meshing curve 13 (Line)
Info    : Meshing curve 14 (Line)
Info    : Meshing curve 15 (Line)
Info    : Meshing curve 16 (Line)
Info    : Meshing curve 17 (Line)
Info    : Done meshing 1D (0.001725 s)
Info    : Meshing 2D...
Info    : Meshing surface 19 (Plane, Delaunay)
Info    : Meshing surface 21 (Plane, Delaunay)
Info    : Meshing surface 23 (Plane, Delaunay)
Info    : Meshing surface 25 (Plane, Delaunay)
Info    : Meshing surface 27 (Plane, Delaunay)
Info    : Meshing surface 29 (Plane, Delaunay)
Info    : Done meshing 2D (0.473845 s)
Info    : 13685 vertices 27682 elements
Info    : Writing './toto.msh'...
Info    : Done writing './toto.msh'
Info    : Stopped on Wed May 10 07:11:59 2017
  -> done!
```

4 ooGmsh class

The ooGmsh class can be used to read `gmsh` mesh files with the MSH ASCII file format described for example in [1], section 9.1.

In a .msh file the kind of mesh elements are identified by their *elm-type* integer values :

elm-type	**description**
1	2-node line
2	3-node triangle
3	4-node quadrangle
4	4-node tetrahedron
5	8-node hexahedron
6	6-node prism
7	5-node pyramid
8	3-node second order line (2 nodes associated with the vertices and 1 with the edge)
9	6-node second order triangle (3 nodes associated with the vertices and 3 with the edges)

10	9-node second order quadrangle (4 nodes associated with the vertices, 4 with the edges and 1 with the face)
11	10-node second order tetrahedron (4 nodes associated with the vertices and 6 with the edges)
12	27-node second order hexahedron (8 nodes associated with the vertices, 12 with the edges, 6 with the faces and 1 with the volume)
13	18-node second order prism (6 nodes associated with the vertices, 9 with the edges and 3 with the quadrangular faces)
14	14-node second order pyramid (5 nodes associated with the vertices, 8 with the edges and 1 with the quadrangular face)
15	1-node point
16	8-node second order quadrangle (4 nodes associated with the vertices and 4 with the edges)
17	20-node second order hexahedron (8 nodes associated with the vertices and 12 with the edges)
18	15-node second order prism (6 nodes associated with the vertices and 9 with the edges)
19	13-node second order pyramid (5 nodes associated with the vertices and 8 with the edges)
20	9-node third order incomplete triangle (3 nodes associated with the vertices, 6 with the edges)
21	10-node third order triangle (3 nodes associated with the vertices, 6 with the edges, 1 with the face)
22	12-node fourth order incomplete triangle (3 nodes associated with the vertices, 9 with the edges)
23	15-node fourth order triangle (3 nodes associated with the vertices, 9 with the edges, 3 with the face)
24	15-node fifth order incomplete triangle (3 nodes associated with the vertices, 12 with the edges)
25	21-node fifth order complete triangle (3 nodes associated with the vertices, 12 with the edges, 6 with the face)
26	4-node third order edge (2 nodes associated with the vertices, 2 internal to the edge)
27	5-node fourth order edge (2 nodes associated with the vertices, 3 internal to the edge)
28	6-node fifth order edge (2 nodes associated with the vertices, 4 internal to the edge)
29	20-node third order tetrahedron (4 nodes associated with the vertices, 12 with the edges, 4 with the faces)
30	35-node fourth order tetrahedron (4 nodes associated with the vertices, 18 with the edges, 12 with the faces, 1 in the volume)
31	56-node fifth order tetrahedron (4 nodes associated with the vertices, 24 with the edges, 24 with the faces, 4 in the volume)
92	64-node third order hexahedron (8 nodes associated with the vertices, 24 with the edges, 24 with the faces, 8 in the volume)

93	125-node fourth order hexahedron (8 nodes associated with the vertices, 36 with the edges, 54 with the faces, 27 in the volume)

When reading a .msh file generated by `gmsh`, we split the mesh elements by *elm-type* and generate an array of Elmt structure. The dimension of this array is the number of differents *elm-type* founds on the .msh file. The `Elmt` structure is given by

Fields of `Elmt` structure

type	:	integer refers to the type of the element : 1 for 2-node line, 2 for 3-node triangle, ... See the *elm-type* description of [1], section 9.1.
geo	:	string contains the kind of geometry: 'line', 'triangle', 'tetrahedron', ...
d	:	integer space dimension or d-simplex.
order	:	integer order of the element
$\mathrm{n_{me}}$	:	integer number of mesh elements
me	:	array of $d+1$-by-$\mathrm{n_{me}}$ integers connectivity array
phys_lab	:	array of $\mathrm{n_{me}}$-by-... integers physical labels of the elements
geo_lab	:	array of $\mathrm{n_{me}}$-by-... integers geometrical labels of the elements
nb_parts	:	array of $\mathrm{n_{me}}$-by-1 integers number of mesh partitions to which the element belongs
part_lab	:	array of $\mathrm{n_{me}}$-by-max(nb_parts) integers part_lab$(i, 1 : \mathrm{nb_parts}(i))$ contains all the partitions index to which the i-th element belongs.

The ooGmsh class was created to store a maximum of(all the) information(s) contained in the .msh file. The properties of this class are:

Properties of ooGmsh class

dim	:	integer space dimension
n_q	:	integer number of vertices/nodes
q	:	dim-by-n_q array of reals array of vertex coordinates
types	:	array of integers List of the element types found in the mesh file.
orders	:	array of integers List of the orders of the element types found in the mesh file.
sElts	:	array of `Elmt` structure One `Elmt` structure by element type, such that sElts(i) contains all the elements of type types(i) and order orders(i).

The ooGmsh class have only one constructor :

```
Gh=ooGmsh(meshfile)
```

where meshfile is the name of ... a mesh file

4.1 Sample 1

The 2d .geo file *condenser.geo* is used to create a .msh file : `condenser-25.msh`. This `.msh` file contains only 1 (2-node line) and 2 (3-node triangle) *elm-type*.

Python commands with output

```
meshfile=gmsh.buildmesh2d('condenser',25);
Gh = gmsh.ooGmsh(meshfile)
print('*** Gh:')
print(Gh)
print('*** Gh.sElts[0]:')
print(Gh.sElts[0])
```

```
 Mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/condenser-25.msh already exist.
  -> Use "force" flag to rebuild if needed.
*** Gh:
ooGmsh object
   dim : 2
 types : [ 1 2 15]
orders : [1]
    nq : 55670
     q : ndarray object[float64], size (55670, 2)
toGlobal: ndarray object[int64], size (55670,)
  sElts : list of 3 elements
*** Gh.sElts[0]:
Elt object
     d : 1, type : 1, order : 1
   geo : line
   nme : 1486
    me : ndarray object[int64], size (2, 1486)
phys_lab: ndarray object[int64], size (1486,)
geo_lab : ndarray object[int64], size (1486,)
part_lab: list of 1486 elements
nb_parts: ndarray object[int64], size (1486,)
  nTags : list of 0 elements
```

4.2 Sample 2

The 3d .geo file *cylinderkey.geo* is used to create a .msh file : `cylinderkey-10.msh`. This `.msh` file contains 1 (2-node line), 2 (3-node triangle) and 4 (4-node tetrahedron) *elm-type*.

Python commands with output

```
meshfile=gmsh.buildmesh3d('cylinderkey',10, force=True)
Gh = gmsh.ooGmsh(meshfile)
print('*** Gh:')
print(Gh)
print('*** Gh.sElts[1]:')
print(Gh.sElts[1])
```

```
 Overwritting mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/cylinderkey-10.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -3 -setnumber N 10
       /fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3d/cylinderkey.geo -o
       /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/cylinderkey-10.msh' [Gmsh 2.16.0, 1 node, max. 1 thread]
Info    : Started on Wed May 10 07:12:00 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3d/cylinderkey.geo'...
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3d/options01_data.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3d/options01_data.geo'
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3d/cylinderkey.geo'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Meshing curve 3 (Circle)
Info    : Meshing curve 4 (Circle)
Info    : Meshing curve 5 (Circle)
Info    : Meshing curve 6 (Circle)
Info    : Meshing curve 7 (Circle)
Info    : Meshing curve 8 (Line)
Info    : Meshing curve 9 (Line)
Info    : Meshing curve 10 (Line)
Info    : Meshing curve 11 (Line)
Info    : Meshing curve 12 (Line)
Info    : Meshing curve 13 (Line)
Info    : Meshing curve 14 (Circle)
Info    : Meshing curve 15 (Circle)
Info    : Meshing curve 16 (Circle)
Info    : Meshing curve 17 (Circle)
Info    : Meshing curve 18 (Circle)
Info    : Meshing curve 19 (Circle)
Info    : Meshing curve 20 (Circle)
Info    : Meshing curve 29 (Circle)
Info    : Meshing curve 30 (Circle)
Info    : Meshing curve 31 (Circle)
Info    : Meshing curve 32 (Circle)
Info    : Meshing curve 65 (Line)
Info    : Meshing curve 66 (Line)
Info    : Meshing curve 67 (Line)
Info    : Meshing curve 68 (Line)
Info    : Meshing curve 69 (Line)
Info    : Meshing curve 70 (Line)
Info    : Meshing curve 71 (Line)
Info    : Meshing curve 72 (Line)
Info    : Meshing curve 73 (Line)
Info    : Meshing curve 74 (Line)
Info    : Meshing curve 75 (Line)
Info    : Meshing curve 76 (Line)
Info    : Meshing curve 1005 (Circle)
Info    : Meshing curve 1007 (Circle)
Info    : Meshing curve 1008 (Circle)
Info    : Meshing curve 1009 (Circle)
Info    : Meshing curve 1010 (Circle)
Info    : Meshing curve 1011 (Circle)
Info    : Meshing curve 1012 (Circle)
Info    : Meshing curve 1013 (Circle)
Info    : Meshing curve 1014 (Circle)
Info    : Meshing curve 1015 (Circle)
Info    : Meshing curve 1016 (Circle)
Info    : Meshing curve 1017 (Circle)
Info    : Meshing curve 1018 (Line)
Info    : Meshing curve 1019 (Line)
Info    : Meshing curve 1020 (Circle)
Info    : Meshing curve 1021 (Line)
Info    : Meshing curve 1022 (Line)
Info    : Meshing curve 1023 (Line)
Info    : Meshing curve 1024 (Circle)
Info    : Meshing curve 1025 (Line)
Info    : Meshing curve 1026 (Circle)
Info    : Meshing curve 1027 (Circle)
Info    : Meshing curve 1028 (Circle)
Info    : Meshing curve 1029 (Circle)
Info    : Done meshing 1D (0.013749 s)
Info    : Meshing 2D...
Info    : Meshing surface 27 (Plane, Delaunay)
Info    : Meshing surface 28 (Plane, Delaunay)
Info    : Meshing surface 34 (Plane, Delaunay)
Info    : Meshing surface 1006 (Plane, Delaunay)
Info    : Meshing surface 1030 (Plane, Delaunay)
Info    : Meshing surface 1036 (Plane, Delaunay)
Info    : Meshing surface 1038 (Plane, Delaunay)
Info    : Meshing surface 1040 (Plane, Delaunay)
Info    : Meshing surface 1042 (Plane, Delaunay)
Info    : Meshing surface 1044 (Plane, Delaunay)
Info    : Meshing surface 1046 (Plane, Delaunay)
Info    : Meshing surface 1048 (Plane, Delaunay)
Info    : Meshing surface 1050 (Ruled surface, MeshAdapt)
Info    : Meshing surface 1052 (Ruled surface, MeshAdapt)
Info    : Meshing surface 1054 (Ruled surface, MeshAdapt)
Info    : Meshing surface 1056 (Ruled surface, MeshAdapt)
Info    : Meshing surface 1058 (Ruled surface, MeshAdapt)
Info    : Meshing surface 1060 (Ruled surface, MeshAdapt)
Info    : Done meshing 2D (0.4849 s)
Info    : Meshing 3D...
Info    : Delaunay Meshing 1 volumes with 1 connected components
Info    : Meshing volume 1062 (Delaunay)
Delaunizing vertices...
Delaunay seconds: 0.031038
Creating surface mesh ...
Surface mesh seconds: 0.008429
Recovering boundaries...
Boundary recovery seconds: 0.013744
Removing exterior tetrahedra ...
Exterior tets removal seconds: 0.004457
```

4.3 Sample 3

The 3d .geo file *sphere8surf.geo* is used to create a 3d surface .msh file : `sphere8surf-40.msh`. This `.msh` file contains 1 (2-node line), 2 (3-node triangle) and 15 (1-node point) *elm-type*.

Python commands with output

```
meshfile=gmsh.buildmesh3ds('sphere8surf',40,force=True)
Gh = gmsh.ooGmsh(meshfile)
print('*** Gh:')
print(Gh)
print('*** Gh.sElts[0]:')
print(Gh.sElts[0])
```

```
 Overwritting mesh file /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/sphere8surf-40.msh
 Running gmsh. Be patient...
Info    : Running '/home/cuvelier/bin/gmsh -2 -setnumber N 40
       /fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3ds/sphere8surf.geo -o
       /fcopt/python3.6.0/lib/python3.6/site-packages/meshes/sphere8surf-40.msh' [Gmsh 2.16.0, 1 node, max. 1 thread]
Info    : Started on Wed May 10 07:12:01 2017
Info    : Reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3ds/sphere8surf.geo'...
Info    : Done reading '/fcopt/python3.6.0/lib/python3.6/site-packages/fc_oogmsh/geodir/3ds/sphere8surf.geo'
Info    : Finalized high order topology of periodic connections
Info    : Meshing 1D...
Info    : Meshing curve 1 (Circle)
Info    : Meshing curve 2 (Circle)
Info    : Meshing curve 3 (Circle)
Info    : Meshing curve 4 (Circle)
Info    : Meshing curve 5 (Circle)
Info    : Meshing curve 6 (Circle)
Info    : Meshing curve 7 (Circle)
Info    : Meshing curve 8 (Circle)
Info    : Meshing curve 9 (Circle)
Info    : Meshing curve 10 (Circle)
Info    : Meshing curve 11 (Circle)
Info    : Meshing curve 12 (Circle)
Info    : Done meshing 1D (0.00277 s)
Info    : Meshing 2D...
Info    : Meshing surface 1 (Ruled surface, MeshAdapt)
Info    : Meshing surface 2 (Ruled surface, MeshAdapt)
Info    : Meshing surface 3 (Ruled surface, MeshAdapt)
Info    : Meshing surface 4 (Ruled surface, MeshAdapt)
Info    : Meshing surface 5 (Ruled surface, MeshAdapt)
Info    : Meshing surface 6 (Ruled surface, MeshAdapt)
Info    : Meshing surface 7 (Ruled surface, MeshAdapt)
Info    : Meshing surface 8 (Ruled surface, MeshAdapt)
Info    : Done meshing 2D (9.25399 s)
Info    : 23313 vertices 47383 elements
Info    : Writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/sphere8surf-40.msh'...
Info    : Done writing '/fcopt/python3.6.0/lib/python3.6/site-packages/meshes/sphere8surf-40.msh'
Info    : Stopped on Wed May 10 07:12:11 2017
  -> done!
*** Gh:
ooGmsh object
    dim : 3
  types : [ 1 2 15]
 orders : [1]
     nq : 23312
      q : ndarray object[float64], size (23312, 3)
toGlobal: ndarray object[int64], size (23312,)
  sElts : list of 3 elements
*** Gh.sElts[0]:
Elt object
      d : 1, type : 1, order : 1
    geo : line
    nme : 756
     me : ndarray object[int64], size (2, 756)
phys_lab: ndarray object[int64], size (756,)
geo_lab : ndarray object[int64], size (756,)
part_lab: list of 756 elements
nb_parts: ndarray object[int64], size (756,)
  nTags : list of 0 elements
```

References

[1] Gmsh 2.15.0. `http://gmsh.info`, 2016.

[2] C. Geuzaine and J.-F. Remacle. Gmsh: A 3-D finite element mesh generator with built-in pre- and post-processing facilities. *International Journal for Numerical Methods in Engineering*, 79(11):1309–1331, 2009.