MyFEM

Contents

Chapter 1

4EM30 Finite Element program

This repository contains the Finite Element program to be used for the second assignment of the 4EM30 Scientific Computing for Mechanical Engineering course.

Main program

The main program can be found in the **myfem.py** file and can be executed using Python 3 (**python myfem.py**)

Modules

The following modules are used for this finite element program:

- **myFElib** This module contains the basic finite element data structures

- **myIOlib** This module contains a mesh reader and basic plotting function

- **myLinAlglib** This module contains the linear system class

- **mymodelslib** This module contains the finite element fluid flow model

Supplementary data

- **meshes** The meshes directory contains various finite element meshes

- **output** The default (empty) output directory

Documentation

Documentation is available in the **doc** directory:

- **html/index.html** can be opened to browse the documentation

- **latex/refman.pdf** contains the LaTeX generated reference manual

Chapter 2

Namespace Index

2.1 Packages

Here are the packages with brief descriptions (if available):

Chapter 3

Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 4

Namespace Documentation

4.1 myFElib Namespace Reference

This module contains the basic finite element data structures.

Classes

- class Element

  Isoparametric finite element.
- class Mesh

  Finite element mesh.
- class Node

  Finite element node.
- class StandardTriangle

  Finite element triangular parent element.

4.1.1 Detailed Description

This module contains the basic finite element data structures.

4.2 myIOlib Namespace Reference

This module contains a mesh reader and basic plotting function.

Functions

- def read_from_txt (fname)

  Mesh file reader.
- def plot_solution (mesh, sol, outfile)

  Plot the solution on a finite element mesh.

4.2.1 Detailed Description

This module contains a mesh reader and basic plotting function.

4.2.2 Function Documentation

4.2.2.1 plot_solution()

```
def myIOlib.plot_solution (
            mesh,
            sol,
            outfile )
```

Plot the solution on a finite element mesh.

Parameters

mesh	Finite element mesh
sol	Solution vector
outfile	Name of the output file

4.2.2.2 read_from_txt()

```
def myIOlib.read_from_txt (
            fname )
```

Mesh file reader.

Parameters

fname	Name of the mesh file

Returns

> Finite element mesh
> Indices of constrained degrees of freedom

4.3 myLinAlglib Namespace Reference

This module contains the linear system class.

Classes

- class LinearSystem

    Linear system of equations.

4.3.1 Detailed Description

This module contains the linear system class.

4.4 mymodelslib Namespace Reference

This module contains the finite element fluid flow model.

Classes

- class PipeFlow

    Fluid flow finite element model.

4.4.1 Detailed Description

This module contains the finite element fluid flow model.

Chapter 5

Class Documentation

5.1   myFElib.Element Class Reference

Isoparametric finite element.

Public Member Functions

- def __init__ (self, ID, parent, nodes)

  Constructor.
- def __iter__ (self)

  Iterator function.
- def __len__ (self)

  Length function.
- def __getitem__ (self, index)

  Get item function.
- def __str__ (self)

  String function.
- def get_nr_of_nodes (self)

  Get the number of nodes.
- def get_dofs (self)

  Get the vector of Dof indices.
- def get_coordinates (self)

  Get the matrix of nodal coordinates.
- def get_coordinate (self, xi)

  Get the global coordinate.
- def get_integration_scheme (self, name, npts)

  Get the integration scheme.
- def get_shapes (self, xi)

  Get the shape functions.
- def get_shapes_gradient (self, xi)

  Get the shape functions gradient.

5.1.1 Detailed Description

Isoparametric finite element.

Maps a standard (parent) element using a node-based parametric map

5.1.2 Constructor & Destructor Documentation

5.1.2.1 __init__()

```
def myFElib.Element.__init__ (
            self,
            ID,
            parent,
            nodes )
```

Constructor.

Parameters

ID	Element ID
parent	Standard/parent element
nodes	List of finite element Nodes

5.1.3 Member Function Documentation

5.1.3.1 get_coordinate()

```
def myFElib.Element.get_coordinate (
            self,
            xi )
```

Get the global coordinate.

Parameters

xi	Local coordinate vector

Returns

Global coordinate vector

5.1.3.2 get_integration_scheme()

```
def myFElib.Element.get_integration_scheme (
            self,
            name,
            npts )
```

Get the integration scheme.

Parameters

name	The type of integration scheme (e.g. 'gauss')
npts	The number of integration points

Returns

> Matrix of integration point coordinates
> Vector of integration point weights

5.1.3.3 get_shapes()

```
def myFElib.Element.get_shapes (
            self,
            xi )
```

Get the shape functions.

Parameters

xi	Local coordinate vector

Returns

> Vector of shape functions

5.1.3.4 get_shapes_gradient()

```
def myFElib.Element.get_shapes_gradient (
            self,
            xi )
```

Get the shape functions gradient.

Parameters

xi	Local coordinate vector

Returns

Matrix of shape function gradients

The documentation for this class was generated from the following file:

- myFElib.py

5.2 myLinAlglib.LinearSystem Class Reference

Linear system of equations.

Public Member Functions

- def __init__ (self, size, zerocons)

    Constructor.
- def __len__ (self)

    Length function.
- def add (self, vec, mat, rdofs, cdofs=None)

    Add contribution to the linear system.
- def add_to_rhs (self, vec, rdofs)

    Add contribution to the right-hand-side.
- def add_to_lhs (self, mat, rdofs, cdofs=None)

    Add contribution to the left-hand-side.
- def solve (self)

    Solve the constrained linear system of equations.

5.2.1 Detailed Description

Linear system of equations.

5.2.2 Constructor & Destructor Documentation

5.2.2.1 __init__()

```
def myLinAlglib.LinearSystem.__init__ (
            self,
            size,
            zerocons )
```

Constructor.

Parameters

size	Number of degrees of freedom
zerocons	Indices of constrained degrees of freedom

5.2.3 Member Function Documentation

5.2.3.1 add()

```
def myLinAlglib.LinearSystem.add (
            self,
            vec,
            mat,
            rdofs,
            cdofs = None )
```

Add contribution to the linear system.

Parameters

vec	Vector to be added to the right-hand-side
mat	Matrix to be added to the left-hand-side
rdofs	Row degrees of freedom to add to
cdofs	Column degrees of freedom to add to

5.2.3.2 add_to_lhs()

```
def myLinAlglib.LinearSystem.add_to_lhs (
            self,
            mat,
            rdofs,
            cdofs = None )
```

Add contribution to the left-hand-side.

Parameters

mat	Matrix to be added to the left-hand-side
rdofs	Row degrees of freedom to add to
cdofs	Column degrees of freedom to add to

5.2.3.3 add_to_rhs()

```
def myLinAlglib.LinearSystem.add_to_rhs (
            self,
            vec,
            rdofs )
```

Add contribution to the right-hand-side.

Parameters

vec	Vector to be added to the right-hand-side
rdofs	Row degrees of freedom to add to

5.2.3.4 solve()

```
def myLinAlglib.LinearSystem.solve (
            self )
```

Solve the constrained linear system of equations.

Returns

Solution vector

The documentation for this class was generated from the following file:

- myLinAlglib.py

5.3 myFElib.Mesh Class Reference

Finite element mesh.

Public Member Functions

- def __init__ (self, nodes, elems)
    Constructor.
- def __iter__ (self)
    Iterator function.
- def __len__ (self)
    Length function.
- def __str__ (self)
    String function.
- def get_node (self, ID)
    Get a node.
- def get_nodal_coordinates (self)
    Get all nodal coordinates.
- def get_connectivity (self)
    Get the element connectivity table.
- def get_nr_of_nodes (self)
    Get the number of nodes.

5.3.1 Detailed Description

Finite element mesh.

5.3.2 Constructor & Destructor Documentation

5.3.2.1 __init__()

```
def myFElib.Mesh.__init__ (
            self,
            nodes,
            elems )
```

Constructor.

Parameters

nodes	list of finite element nodes
elems	list of finite elements

5.3.3 Member Function Documentation

5.3.3.1 get_connectivity()

```
def myFElib.Mesh.get_connectivity (
            self )
```

Get the element connectivity table.

Returns

Matrix (int) with element-Dof connectivities

5.3.3.2 get_nodal_coordinates()

```
def myFElib.Mesh.get_nodal_coordinates (
            self )
```

Get all nodal coordinates.

Returns

Matrix of nodal coordinates

5.3.3.3 get_node()

```
def myFElib.Mesh.get_node (
            self,
            ID )
```

Get a node.

Parameters

ID	Node ID

The documentation for this class was generated from the following file:

- myFElib.py

5.4 myFElib.Node Class Reference

Finite element node.

Public Member Functions

- def __init__ (self, ID, coord, dof)

  Constructor.
- def __str__ (self)

  String function.
- def get_ID (self)

  Get the Node ID.
- def get_dof (self)

  Get the Dof index.
- def set_coordinate (self, coord)

  Set the coordinate.
- def get_coordinate (self)

  Get the Node coordinate.

5.4.1 Detailed Description

Finite element node.

5.4.2 Constructor & Destructor Documentation

5.4.2.1 __init__()

```
def myFElib.Node.__init__ (
            self,
            ID,
            coord,
            dof )
```

Constructor.

Parameters

ID	Node ID
coord	Node coordinate
dof	Dof index

5.4.3 Member Function Documentation

5.4.3.1 set_coordinate()

```
def myFElib.Node.set_coordinate (
            self,
            coord )
```

Set the coordinate.

Parameters

coord	Node coordinate

The documentation for this class was generated from the following file:

- myFElib.py

5.5 mymodelslib.PipeFlow Class Reference

Fluid flow finite element model.

Public Member Functions

- def __init__ (self, params, mesh, cons)
    Constructor.
- def assemble (self)
    Assemble the finite element system.

5.5.1 Detailed Description

Fluid flow finite element model.

5.5.2 Constructor & Destructor Documentation

5.5.2.1 __init__()

```
def mymodelslib.PipeFlow.__init__ (
            self,
            params,
            mesh,
            cons )
```

Constructor.

Parameters

params	Dictionary of model parameters
mesh	Finite element mesh
cons	Indices of constrained degrees of freedom

5.5.3 Member Function Documentation

5.5.3.1 assemble()

```
def mymodelslib.PipeFlow.assemble (
            self )
```

Assemble the finite element system.

Returns

> Linear system of equations

The documentation for this class was generated from the following file:

- mymodelslib.py

5.6   myFElib.StandardTriangle Class Reference

Finite element triangular parent element.

Public Member Functions

- def __len__ (self)
    Length function.
- def get_nr_of_nodes (self)
    Get the number of nodes.
- def get_shapes (self, xi)
    Get the shape functions.
- def get_shapes_gradient (self, xi)
    Get the shape functions gradient.
- def get_integration_scheme (self, name, npts)
    Get the integration scheme.

5.6.1 Detailed Description

Finite element triangular parent element.

Linear triangle parent element with local coordinates (0,0), (1,0), (0,1)

5.6.2 Member Function Documentation

5.6.2.1 get_integration_scheme()

```
def myFElib.StandardTriangle.get_integration_scheme (
            self,
            name,
            npts )
```

Get the integration scheme.

Parameters

name	The type of integration scheme (e.g. 'gauss')
npts	The number of integration points

Returns

> Matrix of integration point coordinates
> Vector of integration point weights

5.6.2.2 get_shapes()

```
def myFElib.StandardTriangle.get_shapes (
            self,
            xi )
```

Get the shape functions.

Parameters

xi	Local coordinate vector

Returns

> Vector of shape functions

5.6.2.3 get_shapes_gradient()

```
def myFElib.StandardTriangle.get_shapes_gradient (
            self,
            xi )
```

Get the shape functions gradient.

Parameters

xi	Local coordinate vector

Returns

Matrix of shape function gradients

The documentation for this class was generated from the following file:

- myFElib.py