
Numpy stl Documentation

Release 2.5.0

Rick van Hattem

Jun 02, 2018

Contents

1	numpy-stl	3
1.1	Links	3
1.2	Requirements for installing:	3
1.3	Installation:	3
1.4	Initial usage:	4
1.5	Contributing:	4
1.6	Quickstart	4
1.7	Plotting using matplotlib is equally easy:	4
1.8	Modifying Mesh objects	5
1.9	Extending Mesh objects	6
1.10	Creating Mesh objects from a list of vertices and faces	7
1.11	Evaluating Mesh properties (Volume, Center of gravity, Inertia)	8
1.12	Combining multiple STL files	8
2	tests and examples	11
2.1	tests.stl_corruption module	11
2.2	tests.test_commandline module	14
2.3	tests.test_convert module	15
2.4	tests.test_mesh module	16
2.5	tests.test_multiple module	20
2.6	tests.test_rotate module	21
3	stl package	27
3.1	stl.Mesh	27
3.2	stl.main module	30
3.3	stl.base module	30
3.4	stl.mesh module	35
3.5	stl.stl module	38
4	Indices and tables	43
	Python Module Index	45

Contents:

Simple library to make working with STL files (and 3D objects in general) fast and easy.

Due to all operations heavily relying on *numpy* this is one of the fastest STL editing libraries for Python available.

1.1 Links

- The source: <https://github.com/WoLpH/numpy-stl>
- Project page: <https://pypi.python.org/pypi/numpy-stl>
- Reporting bugs: <https://github.com/WoLpH/numpy-stl/issues>
- Documentation: <http://numpy-stl.readthedocs.org/en/latest/>
- My blog: <https://wol.ph/>

1.2 Requirements for installing:

- `numpy` any recent version
- `python-utils` version 1.6 or greater

1.3 Installation:

pip install numpy-stl

1.4 Initial usage:

- `stl2bin your_ascii_stl_file.stl new_binary_stl_file.stl`
- `stl2ascii your_binary_stl_file.stl new_ascii_stl_file.stl`
- `stl your_ascii_stl_file.stl new_binary_stl_file.stl`

1.5 Contributing:

Contributions are always welcome. Please view the guidelines to get started: <https://github.com/WoLpH/numpy-stl/blob/develop/CONTRIBUTING.rst>

1.6 Quickstart

```
import numpy
from stl import mesh

# Using an existing stl file:
your_mesh = mesh.Mesh.from_file('some_file.stl')

# Or creating a new mesh (make sure not to overwrite the `mesh` import by
# naming it `mesh`):
VERTICE_COUNT = 100
data = numpy.zeros(VERTICE_COUNT, dtype=mesh.Mesh.dtype)
your_mesh = mesh.Mesh(data, remove_empty_areas=False)

# The mesh normals (calculated automatically)
your_mesh.normals

# The mesh vectors
your_mesh.v0, your_mesh.v1, your_mesh.v2
# Accessing individual points (concatenation of v0, v1 and v2 in triplets)
assert (your_mesh.points[0][0:3] == your_mesh.v0[0]).all()
assert (your_mesh.points[0][3:6] == your_mesh.v1[0]).all()
assert (your_mesh.points[0][6:9] == your_mesh.v2[0]).all()
assert (your_mesh.points[1][0:3] == your_mesh.v0[1]).all()

your_mesh.save('new_stl_file.stl')
```

1.7 Plotting using matplotlib is equally easy:

```
from stl import mesh
from mpl_toolkits import mplot3d
from matplotlib import pyplot

# Create a new plot
figure = pyplot.figure()
axes = mplot3d.Axes3D(figure)

# Load the STL files and add the vectors to the plot
```

(continues on next page)

(continued from previous page)

```

your_mesh = mesh.Mesh.from_file('tests/stl_binary/HalfDonut.stl')
axes.add_collection3d(mplot3d.art3d.Poly3DCollection(your_mesh.vectors))

# Auto scale to the mesh size
scale = your_mesh.points.flatten(-1)
axes.auto_scale_xyz(scale, scale, scale)

# Show the plot to the screen
pyplot.show()

```

1.8 Modifying Mesh objects

```

from stl import mesh
import math
import numpy

# Create 3 faces of a cube
data = numpy.zeros(6, dtype=mesh.Mesh.dtype)

# Top of the cube
data['vectors'][0] = numpy.array([[0, 1, 1],
                                  [1, 0, 1],
                                  [0, 0, 1]])
data['vectors'][1] = numpy.array([[1, 0, 1],
                                  [0, 1, 1],
                                  [1, 1, 1]])

# Right face
data['vectors'][2] = numpy.array([[1, 0, 0],
                                  [1, 0, 1],
                                  [1, 1, 0]])
data['vectors'][3] = numpy.array([[1, 1, 1],
                                  [1, 0, 1],
                                  [1, 1, 0]])

# Left face
data['vectors'][4] = numpy.array([[0, 0, 0],
                                  [1, 0, 0],
                                  [1, 0, 1]])
data['vectors'][5] = numpy.array([[0, 0, 0],
                                  [0, 0, 1],
                                  [1, 0, 1]])

# Since the cube faces are from 0 to 1 we can move it to the middle by
# subtracting .5
data['vectors'] -= .5

# Generate 4 different meshes so we can rotate them later
meshes = [mesh.Mesh(data.copy()) for _ in range(4)]

# Rotate 90 degrees over the Y axis
meshes[0].rotate([0.0, 0.5, 0.0], math.radians(90))

# Translate 2 points over the X axis
meshes[1].x += 2

```

(continues on next page)

(continued from previous page)

```

# Rotate 90 degrees over the X axis
meshes[2].rotate([0.5, 0.0, 0.0], math.radians(90))
# Translate 2 points over the X and Y points
meshes[2].x += 2
meshes[2].y += 2

# Rotate 90 degrees over the X and Y axis
meshes[3].rotate([0.5, 0.0, 0.0], math.radians(90))
meshes[3].rotate([0.0, 0.5, 0.0], math.radians(90))
# Translate 2 points over the Y axis
meshes[3].y += 2

# Optionally render the rotated cube faces
from matplotlib import pyplot
from mpl_toolkits import mplot3d

# Create a new plot
figure = pyplot.figure()
axes = mplot3d.Axes3D(figure)

# Render the cube faces
for m in meshes:
    axes.add_collection3d(mplot3d.art3d.Poly3DCollection(m.vectors))

# Auto scale to the mesh size
scale = numpy.concatenate([m.points for m in meshes]).flatten(-1)
axes.auto_scale_xyz(scale, scale, scale)

# Show the plot to the screen
pyplot.show()

```

1.9 Extending Mesh objects

```

from stl import mesh
import math
import numpy

# Create 3 faces of a cube
data = numpy.zeros(6, dtype=mesh.Mesh.dtype)

# Top of the cube
data['vectors'][0] = numpy.array([[0, 1, 1],
                                  [1, 0, 1],
                                  [0, 0, 1]])
data['vectors'][1] = numpy.array([[1, 0, 1],
                                  [0, 1, 1],
                                  [1, 1, 1]])

# Right face
data['vectors'][2] = numpy.array([[1, 0, 0],
                                  [1, 0, 1],
                                  [1, 1, 0]])
data['vectors'][3] = numpy.array([[1, 1, 1],
                                  [1, 0, 1],

```

(continues on next page)

(continued from previous page)

```

                                [1, 1, 0]])
# Left face
data['vectors'][4] = numpy.array([[0, 0, 0],
                                [1, 0, 0],
                                [1, 0, 1]])
data['vectors'][5] = numpy.array([[0, 0, 0],
                                [0, 0, 1],
                                [1, 0, 1]])

# Since the cube faces are from 0 to 1 we can move it to the middle by
# subtracting .5
data['vectors'] -= .5

cube_back = mesh.Mesh(data.copy())
cube_front = mesh.Mesh(data.copy())

# Rotate 90 degrees over the X axis followed by the Y axis followed by the
# X axis
cube_back.rotate([0.5, 0.0, 0.0], math.radians(90))
cube_back.rotate([0.0, 0.5, 0.0], math.radians(90))
cube_back.rotate([0.5, 0.0, 0.0], math.radians(90))

cube = mesh.Mesh(numpy.concatenate([
    cube_back.data.copy(),
    cube_front.data.copy(),
]))

# Optionally render the rotated cube faces
from matplotlib import pyplot
from mpl_toolkits import mplot3d

# Create a new plot
figure = pyplot.figure()
axes = mplot3d.Axes3D(figure)

# Render the cube
axes.add_collection3d(mplot3d.art3d.Poly3DCollection(cube.vectors))

# Auto scale to the mesh size
scale = cube_back.points.flatten(-1)
axes.auto_scale_xyz(scale, scale, scale)

# Show the plot to the screen
pyplot.show()

```

1.10 Creating Mesh objects from a list of vertices and faces

```

import numpy as np
from stl import mesh

# Define the 8 vertices of the cube
vertices = np.array([\
    [-1, -1, -1],
    [+1, -1, -1],

```

(continues on next page)

(continued from previous page)

```

    [+1, +1, -1],
    [-1, +1, -1],
    [-1, -1, +1],
    [+1, -1, +1],
    [+1, +1, +1],
    [-1, +1, +1]])
# Define the 12 triangles composing the cube
faces = np.array([\
    [0,3,1],
    [1,3,2],
    [0,4,7],
    [0,7,3],
    [4,5,6],
    [4,6,7],
    [5,1,2],
    [5,2,6],
    [2,3,6],
    [3,7,6],
    [0,1,5],
    [0,5,4]])

# Create the mesh
cube = mesh.Mesh(np.zeros(faces.shape[0], dtype=mesh.Mesh.dtype))
for i, f in enumerate(faces):
    for j in range(3):
        cube.vectors[i][j] = vertices[f[j],:]

# Write the mesh to file "cube.stl"
cube.save('cube.stl')

```

1.11 Evaluating Mesh properties (Volume, Center of gravity, Inertia)

```

import numpy as np
from stl import mesh

# Using an existing closed stl file:
your_mesh = mesh.Mesh.from_file('some_file.stl')

volume, cog, inertia = your_mesh.get_mass_properties()
print("Volume                               = {}".format(volume))
print("Position of the center of gravity (COG) = {}".format(cog))
print("Inertia matrix at expressed at the COG  = {}".format(inertia[0,:]))
print("                                           {} {}".format(inertia[1,:]))
print("                                           {} {}".format(inertia[2,:]))

```

1.12 Combining multiple STL files

```

import math
import stl
from stl import mesh
import numpy

```

(continues on next page)

(continued from previous page)

```

# find the max dimensions, so we can know the bounding box, getting the height,
# width, length (because these are the step size)...
def find_mins_maxs(obj):
    minx = maxx = miny = maxy = minz = maxz = None
    for p in obj.points:
        # p contains (x, y, z)
        if minx is None:
            minx = p[stl.Dimension.X]
            maxx = p[stl.Dimension.X]
            miny = p[stl.Dimension.Y]
            maxy = p[stl.Dimension.Y]
            minz = p[stl.Dimension.Z]
            maxz = p[stl.Dimension.Z]
        else:
            maxx = max(p[stl.Dimension.X], maxx)
            minx = min(p[stl.Dimension.X], minx)
            maxy = max(p[stl.Dimension.Y], maxy)
            miny = min(p[stl.Dimension.Y], miny)
            maxz = max(p[stl.Dimension.Z], maxz)
            minz = min(p[stl.Dimension.Z], minz)
    return minx, maxx, miny, maxy, minz, maxz

def translate(_solid, step, padding, multiplier, axis):
    if 'x' == axis:
        items = 0, 3, 6
    elif 'y' == axis:
        items = 1, 4, 7
    elif 'z' == axis:
        items = 2, 5, 8
    else:
        raise RuntimeError('Unknown axis %r, expected x, y or z' % axis)

    # _solid.points.shape == [:(x, y, z), (x, y, z), (x, y, z)]
    _solid.points[:, items] += (step * multiplier) + (padding * multiplier)

def copy_obj(obj, dims, num_rows, num_cols, num_layers):
    w, l, h = dims
    copies = []
    for layer in range(num_layers):
        for row in range(num_rows):
            for col in range(num_cols):
                # skip the position where original being copied is
                if row == 0 and col == 0 and layer == 0:
                    continue
                _copy = mesh.Mesh(obj.data.copy())
                # pad the space between objects by 10% of the dimension being
                # translated
                if col != 0:
                    translate(_copy, w, w / 10., col, 'x')
                if row != 0:
                    translate(_copy, l, l / 10., row, 'y')
                if layer != 0:
                    translate(_copy, h, h / 10., layer, 'z')

```

(continues on next page)

(continued from previous page)

```
        copies.append(_copy)
    return copies

# Using an existing stl file:
main_body = mesh.Mesh.from_file('ball_and_socket_simplified_-_main_body.stl')

# rotate along Y
main_body.rotate([0.0, 0.5, 0.0], math.radians(90))

minx, maxx, miny, maxy, minz, maxz = find_mins_maxs(main_body)
w1 = maxx - minx
l1 = maxy - miny
h1 = maxz - minz
copies = copy_obj(main_body, (w1, l1, h1), 2, 2, 1)

# I wanted to add another related STL to the final STL
twist_lock = mesh.Mesh.from_file('ball_and_socket_simplified_-_twist_lock.stl')
minx, maxx, miny, maxy, minz, maxz = find_mins_maxs(twist_lock)
w2 = maxx - minx
l2 = maxy - miny
h2 = maxz - minz
translate(twist_lock, w1, w1 / 10., 3, 'x')
copies2 = copy_obj(twist_lock, (w2, l2, h2), 2, 2, 1)
combined = mesh.Mesh(numpy.concatenate([main_body.data, twist_lock.data] +
                                       [copy.data for copy in copies] +
                                       [copy.data for copy in copies2]))

combined.save('combined.stl', mode=stl.Mode.ASCII) # save as ASCII
```

2.1 tests.stl_corruption module

```
from __future__ import print_function
import numpy
import pytest
import struct

from stl import mesh

_STL_FILE = '''
solid test.stl
facet normal -0.014565 0.073223 -0.002897
  outer loop
    vertex 0.399344 0.461940 1.044090
    vertex 0.500000 0.500000 1.500000
    vertex 0.576120 0.500000 1.117320
  endloop
endfacet
endsolid test.stl
'''.lstrip()

def test_valid_ascii(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('w+') as fh:
        fh.write(_STL_FILE)
        fh.seek(0)
        mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

def test_ascii_with_missing_name(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('w+') as fh:
```

(continues on next page)

(continued from previous page)

```

    # Split the file into lines
    lines = _STL_FILE.splitlines()

    # Remove everything except solid
    lines[0] = lines[0].split()[0]

    # Join the lines to test files that start with solid without space
    fh.write('\n'.join(lines))
    fh.seek(0)
    mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

def test_ascii_with_blank_lines(tmpdir, speedups):
    _stl_file = '''
solid test.stl

    facet normal -0.014565 0.073223 -0.002897

        outer loop

            vertex 0.399344 0.461940 1.044090
            vertex 0.500000 0.500000 1.500000

            vertex 0.576120 0.500000 1.117320

        endloop

    endfacet

endsolid test.stl
'''

    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('w+') as fh:
        fh.write(_stl_file)
        fh.seek(0)
        mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

def test_incomplete_ascii_file(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('w+') as fh:
        fh.write('solid some_file.stl')
        fh.seek(0)
        with pytest.raises(AssertionError):
            mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

    for offset in (-20, 82, 100):
        with tmp_file.open('w+') as fh:
            fh.write(_STL_FILE[:-offset])
            fh.seek(0)
            with pytest.raises(AssertionError):
                mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

def test_corrupt_ascii_file(tmpdir, speedups):

```

(continues on next page)

(continued from previous page)

```

tmp_file = tmpdir.join('tmp.stl')
with tmp_file.open('w+') as fh:
    fh.write(_STL_FILE)
    fh.seek(40)
    print('####\n' * 100, file=fh)
    fh.seek(0)
    with pytest.raises(AssertionError):
        mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

with tmp_file.open('w+') as fh:
    fh.write(_STL_FILE)
    fh.seek(40)
    print(' ' * 100, file=fh)
    fh.seek(80)
    fh.write(struct.pack('<i', 10).decode('utf-8'))
    fh.seek(0)
    with pytest.raises(AssertionError):
        mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

def test_corrupt_binary_file(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('w+') as fh:
        fh.write('#####\n' * 8)
        fh.write('#\0\0\0')
        fh.seek(0)
        mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

    with tmp_file.open('w+') as fh:
        fh.write('#####\n' * 9)
        fh.seek(0)
        with pytest.raises(AssertionError):
            mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

    with tmp_file.open('w+') as fh:
        fh.write('#####\n' * 8)
        fh.write('#\0\0\0')
        fh.seek(0)
        fh.write('solid test.stl')
        fh.seek(0)
        mesh.Mesh.from_file(str(tmp_file), fh=fh, speedups=speedups)

def test_duplicate_polygons():
    data = numpy.zeros(3, dtype=mesh.Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [1, 0, 0],
                                      [0, 1, 1.]])
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [2, 0, 0],
                                      [0, 2, 1.]])
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [3, 0, 0],
                                      [0, 3, 1.]])

    assert not mesh.Mesh(data, remove_empty_areas=False).check()

```

2.2 tests.test_commandline module

```
import sys

from stl import main

def test_main(ascii_file, binary_file, tmpdir, speedups):
    original_argv = sys.argv[:]
    args_pre = ['stl']
    args_post = [str(tmpdir.join('output.stl'))]

    if not speedups:
        args_pre.append('-s')

    try:
        sys.argv[:] = args_pre + [ascii_file] + args_post
        main.main()
        sys.argv[:] = args_pre + ['-r', ascii_file] + args_post
        main.main()
        sys.argv[:] = args_pre + ['-a', binary_file] + args_post
        main.main()
        sys.argv[:] = args_pre + ['-b', ascii_file] + args_post
        main.main()
    finally:
        sys.argv[:] = original_argv

def test_args(ascii_file, tmpdir):
    parser = main._get_parser('')

    def _get_name(*args):
        return main._get_name(parser.parse_args(list(map(str, args))))

    assert _get_name('--name', 'foobar') == 'foobar'
    assert _get_name('-', tmpdir.join('binary.stl')).endswith('binary.stl')
    assert _get_name(ascii_file, '-').endswith('HalfDonut.stl')
    assert _get_name('-', '-')

def test_ascii(binary_file, tmpdir, speedups):
    original_argv = sys.argv[:]
    try:
        sys.argv[:] = [
            'stl',
            '-s' if not speedups else '',
            binary_file,
            str(tmpdir.join('ascii.stl')),
        ]
        try:
            main.to_ascii()
        except SystemExit:
            pass
    finally:
        sys.argv[:] = original_argv
```

(continues on next page)

(continued from previous page)

```

def test_binary(ascii_file, tmpdir, speedups):
    original_argv = sys.argv[:]
    try:
        sys.argv[:] = [
            'stl',
            '-s' if not speedups else '',
            ascii_file,
            str(tmpdir.join('binary.stl')),
        ]
        try:
            main.to_binary()
        except SystemExit:
            pass
    finally:
        sys.argv[:] = original_argv

```

2.3 tests.test_convert module

```

# import os
import pytest
import tempfile

from stl import stl

def _test_conversion(from_, to, mode, speedups):

    for name in from_.listdir():
        source_file = from_.join(name)
        expected_file = to.join(name)
        if not expected_file.exists():
            continue

        mesh = stl.StlMesh(source_file, speedups=speedups)
        with open(str(expected_file), 'rb') as expected_fh:
            expected = expected_fh.read()
            # For binary files, skip the header
            if mode is stl.BINARY:
                expected = expected[80:]

        with tempfile.TemporaryFile() as dest_fh:
            mesh.save(name, dest_fh, mode)
            # Go back to the beginning to read
            dest_fh.seek(0)
            dest = dest_fh.read()
            # For binary files, skip the header
            if mode is stl.BINARY:
                dest = dest[80:]

            assert dest.strip() == expected.strip()

def test_ascii_to_binary(ascii_path, binary_path, speedups):
    _test_conversion(ascii_path, binary_path, mode=stl.BINARY,

```

(continues on next page)

(continued from previous page)

```

        speedups=speedups)

def test_binary_to_ascii(ascii_path, binary_path, speedups):
    _test_conversion(binary_path, ascii_path, mode=stl.ASCII,
                     speedups=speedups)

def test_stl_mesh(ascii_file, tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')

    mesh = stl.StlMesh(ascii_file, speedups=speedups)
    with pytest.raises(ValueError):
        mesh.save(filename=str(tmp_file), mode='test')

    mesh.save(str(tmp_file))
    mesh.save(str(tmp_file), update_normals=False)

```

2.4 tests.test_mesh module

```

import numpy

from stl.mesh import Mesh
from stl.base import BaseMesh
from stl.base import RemoveDuplicates

from . import utils

def test_units_1d():
    data = numpy.zeros(1, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [1, 0, 0],
                                      [2, 0, 0]])

    mesh = Mesh(data, remove_empty_areas=False)
    mesh.update_units()

    assert mesh.areas == 0
    utils.array_equals(mesh.normals, [0, 0, 0])
    utils.array_equals(mesh.units, [0, 0, 0])

def test_units_2d():
    data = numpy.zeros(2, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [1, 0, 0],
                                      [0, 1, 0]])
    data['vectors'][1] = numpy.array([[1, 0, 0],
                                      [0, 1, 0],
                                      [1, 1, 0]])

    mesh = Mesh(data, remove_empty_areas=False)
    mesh.update_units()

```

(continues on next page)

(continued from previous page)

```

assert numpy.allclose(mesh.areas, [.5, .5])
assert numpy.allclose(mesh.normals, [[0, 0, 1.], [0, 0, -1.]])
assert numpy.allclose(mesh.units, [[0, 0, 1], [0, 0, -1]])

def test_units_3d():
    data = numpy.zeros(1, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [1, 0, 0],
                                      [0, 1, 1.]])

    mesh = Mesh(data, remove_empty_areas=False)
    mesh.update_units()

    assert (mesh.areas - 2 ** .5) < 0.0001
    assert numpy.allclose(mesh.normals, [0, -1, 1])

    units = mesh.units[0]
    assert units[0] == 0
    # Due to floating point errors
    assert (units[1] + .5 * 2 ** .5) < 0.0001
    assert (units[2] - .5 * 2 ** .5) < 0.0001

def test_duplicate_polygons():
    data = numpy.zeros(6, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[1, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][1] = numpy.array([[2, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][2] = numpy.array([[0, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][3] = numpy.array([[2, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][4] = numpy.array([[1, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][5] = numpy.array([[0, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])

    mesh = Mesh(data)
    assert mesh.data.size == 6

    mesh = Mesh(data, remove_duplicate_polygons=0)
    assert mesh.data.size == 6

    mesh = Mesh(data, remove_duplicate_polygons=False)
    assert mesh.data.size == 6

    mesh = Mesh(data, remove_duplicate_polygons=None)
    assert mesh.data.size == 6

```

(continues on next page)

(continued from previous page)

```

mesh = Mesh(data, remove_duplicate_polygons=RemoveDuplicates.NONE)
assert mesh.data.size == 6

mesh = Mesh(data, remove_duplicate_polygons=RemoveDuplicates.SINGLE)
assert mesh.data.size == 3

mesh = Mesh(data, remove_duplicate_polygons=True)
assert mesh.data.size == 3

assert numpy.allclose(mesh.vectors[0], numpy.array([[1, 0, 0],
                                                    [0, 0, 0],
                                                    [0, 0, 0]]))
assert numpy.allclose(mesh.vectors[1], numpy.array([[2, 0, 0],
                                                    [0, 0, 0],
                                                    [0, 0, 0]]))
assert numpy.allclose(mesh.vectors[2], numpy.array([[0, 0, 0],
                                                    [0, 0, 0],
                                                    [0, 0, 0]]))

mesh = Mesh(data, remove_duplicate_polygons=RemoveDuplicates.ALL)
assert mesh.data.size == 3

assert numpy.allclose(mesh.vectors[0], numpy.array([[1, 0, 0],
                                                    [0, 0, 0],
                                                    [0, 0, 0]]))
assert numpy.allclose(mesh.vectors[1], numpy.array([[2, 0, 0],
                                                    [0, 0, 0],
                                                    [0, 0, 0]]))
assert numpy.allclose(mesh.vectors[2], numpy.array([[0, 0, 0],
                                                    [0, 0, 0],
                                                    [0, 0, 0]]))

def test_remove_all_duplicate_polygons():
    data = numpy.zeros(5, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][1] = numpy.array([[1, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][2] = numpy.array([[2, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][3] = numpy.array([[3, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])
    data['vectors'][4] = numpy.array([[3, 0, 0],
                                      [0, 0, 0],
                                      [0, 0, 0]])

    mesh = Mesh(data, remove_duplicate_polygons=False)
    assert mesh.data.size == 5
    Mesh.remove_duplicate_polygons(mesh.data, RemoveDuplicates.NONE)

    mesh = Mesh(data, remove_duplicate_polygons=RemoveDuplicates.ALL)

```

(continues on next page)

(continued from previous page)

```

assert mesh.data.size == 3

assert (mesh.vectors[0] == numpy.array([[0, 0, 0],
                                         [0, 0, 0],
                                         [0, 0, 0]])).all()

assert (mesh.vectors[1] == numpy.array([[1, 0, 0],
                                         [0, 0, 0],
                                         [0, 0, 0]])).all()

assert (mesh.vectors[2] == numpy.array([[2, 0, 0],
                                         [0, 0, 0],
                                         [0, 0, 0]])).all()

def test_empty_areas():
    data = numpy.zeros(3, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 0, 0],
                                      [1, 0, 0],
                                      [0, 1, 0]])
    data['vectors'][1] = numpy.array([[1, 0, 0],
                                      [0, 1, 0],
                                      [1, 0, 0]])
    data['vectors'][2] = numpy.array([[1, 0, 0],
                                      [0, 1, 0],
                                      [1, 0, 0]])

    mesh = Mesh(data, remove_empty_areas=False)
    assert mesh.data.size == 3

    mesh = Mesh(data, remove_empty_areas=True)
    assert mesh.data.size == 1

def test_base_mesh():
    data = numpy.zeros(10, dtype=BaseMesh.dtype)
    mesh = BaseMesh(data, remove_empty_areas=False)
    # Increment vector 0 item 0
    mesh.v0[0] += 1
    mesh.v1[0] += 2

    # Check item 0 (contains v0, v1 and v2)
    assert (mesh[0] == numpy.array(
        [1., 1., 1., 2., 2., 2., 0., 0., 0.], dtype=numpy.float32)
    ).all()
    assert (mesh.vectors[0] == numpy.array([
        [1., 1., 1.],
        [2., 2., 2.],
        [0., 0., 0.], dtype=numpy.float32)).all()
    assert (mesh.v0[0] == numpy.array([1., 1., 1.], dtype=numpy.float32)).all()
    assert (mesh.points[0] == numpy.array(
        [1., 1., 1., 2., 2., 2., 0., 0., 0.], dtype=numpy.float32)
    ).all()
    assert (
        mesh.x[0] == numpy.array([1., 2., 0.], dtype=numpy.float32)).all()

    mesh[0] = 3
    assert (mesh[0] == numpy.array(
        [3., 3., 3., 3., 3., 3., 3., 3., 3.], dtype=numpy.float32)

```

(continues on next page)

(continued from previous page)

```

).all()

assert len(mesh) == len(list(mesh))
assert (mesh.min_ < mesh.max_).all()
mesh.update_normals()
assert mesh.units.sum() == 0.0
mesh.v0[:] = mesh.v1[:] = mesh.v2[:] = 0
assert mesh.points.sum() == 0.0

```

2.5 tests.test_multiple module

```

from stl import mesh
from stl.utils import b

_STL_FILE = b('''
solid test.stl
facet normal -0.014565 0.073223 -0.002897
  outer loop
    vertex 0.399344 0.461940 1.044090
    vertex 0.500000 0.500000 1.500000
    vertex 0.576120 0.500000 1.117320
  endloop
endfacet
endsolid test.stl
'''.lstrip())

def test_single_stl(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('wb+') as fh:
        fh.write(_STL_FILE)
        fh.seek(0)
        for m in mesh.Mesh.from_multi_file(
            str(tmp_file), fh=fh, speedups=speedups):
            pass

def test_multiple_stl(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('wb+') as fh:
        for _ in range(10):
            fh.write(_STL_FILE)
            fh.seek(0)
            for i, m in enumerate(mesh.Mesh.from_multi_file(
                str(tmp_file), fh=fh, speedups=speedups)):
                assert m.name == b'test.stl'

        assert i == 9

def test_single_stl_file(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('wb+') as fh:
        fh.write(_STL_FILE)

```

(continues on next page)

(continued from previous page)

```

        fh.seek(0)
        for m in mesh.Mesh.from_multi_file(
            str(tmp_file), speedups=speedups):
            pass

def test_multiple_stl_file(tmpdir, speedups):
    tmp_file = tmpdir.join('tmp.stl')
    with tmp_file.open('wb+') as fh:
        for _ in range(10):
            fh.write(_STL_FILE)

        fh.seek(0)
        for i, m in enumerate(mesh.Mesh.from_multi_file(
            str(tmp_file), speedups=speedups)):
            assert m.name == b'test.stl'

    assert i == 9

```

2.6 tests.test_rotate module

```

import math
import numpy
import pytest

from stl.mesh import Mesh

from . import utils

def test_rotation():
    # Create 6 faces of a cube
    data = numpy.zeros(6, dtype=Mesh.dtype)

    # Top of the cube
    data['vectors'][0] = numpy.array([[0, 1, 1],
                                      [1, 0, 1],
                                      [0, 0, 1]])

    data['vectors'][1] = numpy.array([[1, 0, 1],
                                      [0, 1, 1],
                                      [1, 1, 1]])

    # Right face
    data['vectors'][2] = numpy.array([[1, 0, 0],
                                      [1, 0, 1],
                                      [1, 1, 0]])

    data['vectors'][3] = numpy.array([[1, 1, 1],
                                      [1, 0, 1],
                                      [1, 1, 0]])

    # Left face
    data['vectors'][4] = numpy.array([[0, 0, 0],
                                      [1, 0, 0],
                                      [1, 0, 1]])

```

(continues on next page)

(continued from previous page)

```

data['vectors'][5] = numpy.array([[0, 0, 0],
                                  [0, 0, 1],
                                  [1, 0, 1]])

mesh = Mesh(data, remove_empty_areas=False)

# Since the cube faces are from 0 to 1 we can move it to the middle by
# subtracting .5
data['vectors'] -= .5

# Rotate 90 degrees over the X axis followed by the Y axis followed by the
# X axis
mesh.rotate([0.5, 0.0, 0.0], math.radians(90))
mesh.rotate([0.0, 0.5, 0.0], math.radians(90))
mesh.rotate([0.5, 0.0, 0.0], math.radians(90))

# Since the cube faces are from 0 to 1 we can move it to the middle by
# subtracting .5
data['vectors'] += .5

# We use a slightly higher absolute tolerance here, for ppc64le
# https://github.com/WoLpH/numpy-stl/issues/78
assert numpy.allclose(mesh.vectors, numpy.array([
    [1, 0, 0], [0, 1, 0], [0, 0, 0]],
    [[0, 1, 0], [1, 0, 0], [1, 1, 0]],
    [[0, 1, 1], [0, 1, 0], [1, 1, 1]],
    [[1, 1, 0], [0, 1, 0], [1, 1, 1]],
    [[0, 0, 1], [0, 1, 1], [0, 1, 0]],
    [[0, 0, 1], [0, 0, 0], [0, 1, 0]],
]), atol=1e-07)

def test_rotation_over_point():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)

    data['vectors'][0] = numpy.array([[1, 0, 0],
                                      [0, 1, 0],
                                      [0, 0, 1]])

    mesh = Mesh(data, remove_empty_areas=False)

    mesh.rotate([1, 0, 0], math.radians(180), point=[1, 2, 3])
    utils.array_equals(
        mesh.vectors,
        numpy.array([[1., 4., 6.],
                     [0., 3., 6.],
                     [0., 4., 5.])))

    mesh.rotate([1, 0, 0], math.radians(-180), point=[1, 2, 3])
    utils.array_equals(
        mesh.vectors,
        numpy.array([[1, 0, 0],
                     [0, 1, 0],
                     [0, 0, 1]]))

    mesh.rotate([1, 0, 0], math.radians(180), point=0.0)

```

(continues on next page)

(continued from previous page)

```

utils.array_equals(
    mesh.vectors,
    numpy.array([[1., 0., -0.],
                 [0., -1., -0.],
                 [0., 0., -1.])))

with pytest.raises(TypeError):
    mesh.rotate([1, 0, 0], math.radians(180), point='x')

def test_double_rotation():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)

    data['vectors'][0] = numpy.array([[1, 0, 0],
                                      [0, 1, 0],
                                      [0, 0, 1]])

    mesh = Mesh(data, remove_empty_areas=False)

    rotation_matrix = mesh.rotation_matrix([1, 0, 0], math.radians(180))
    combined_rotation_matrix = numpy.dot(rotation_matrix, rotation_matrix)

    mesh.rotate_using_matrix(combined_rotation_matrix)
    utils.array_equals(
        mesh.vectors,
        numpy.array([[1., 0., 0.],
                     [0., 1., 0.],
                     [0., 0., 1.])))

def test_no_rotation():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)

    data['vectors'][0] = numpy.array([[0, 1, 1],
                                      [1, 0, 1],
                                      [0, 0, 1]])

    mesh = Mesh(data, remove_empty_areas=False)

    # Rotate by 0 degrees
    mesh.rotate([0.5, 0.0, 0.0], math.radians(0))
    assert numpy.allclose(mesh.vectors, numpy.array([
        [0, 1, 1], [1, 0, 1], [0, 0, 1]]))

    # Use a zero rotation matrix
    mesh.rotate([0.0, 0.0, 0.0], math.radians(90))
    assert numpy.allclose(mesh.vectors, numpy.array([
        [0, 1, 1], [1, 0, 1], [0, 0, 1]]))

def test_no_translation():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 1, 1],
                                      [1, 0, 1],

```

(continues on next page)

(continued from previous page)

```

                                [0, 0, 1]])

mesh = Mesh(data, remove_empty_areas=False)
assert numpy.allclose(mesh.vectors, numpy.array([
    [[0, 1, 1], [1, 0, 1], [0, 0, 1]]]))

# Translate mesh with a zero vector
mesh.translate([0.0, 0.0, 0.0])
assert numpy.allclose(mesh.vectors, numpy.array([
    [[0, 1, 1], [1, 0, 1], [0, 0, 1]]]))

def test_translation():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 1, 1],
                                      [1, 0, 1],
                                      [0, 0, 1]])

    mesh = Mesh(data, remove_empty_areas=False)
    assert numpy.allclose(mesh.vectors, numpy.array([
        [[0, 1, 1], [1, 0, 1], [0, 0, 1]]]))

    # Translate mesh with vector [1, 2, 3]
    mesh.translate([1.0, 2.0, 3.0])
    assert numpy.allclose(mesh.vectors, numpy.array([
        [[1, 3, 4], [2, 2, 4], [1, 2, 4]]]))

def test_no_transformation():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 1, 1],
                                      [1, 0, 1],
                                      [0, 0, 1]])

    mesh = Mesh(data, remove_empty_areas=False)
    assert numpy.allclose(mesh.vectors, numpy.array([
        [[0, 1, 1], [1, 0, 1], [0, 0, 1]]]))

    # Transform mesh with identity matrix
    mesh.transform(numpy.eye(4))
    assert numpy.allclose(mesh.vectors, numpy.array([
        [[0, 1, 1], [1, 0, 1], [0, 0, 1]]]))
    assert numpy.allclose(mesh.areas, 0.5)

def test_transformation():
    # Create a single face
    data = numpy.zeros(1, dtype=Mesh.dtype)
    data['vectors'][0] = numpy.array([[0, 1, 1],
                                      [1, 0, 1],
                                      [0, 0, 1]])

    mesh = Mesh(data, remove_empty_areas=False)
    assert numpy.allclose(mesh.vectors, numpy.array([
        [[0, 1, 1], [1, 0, 1], [0, 0, 1]]]))

```

(continues on next page)

(continued from previous page)

```
# Transform mesh with identity matrix
tr = numpy.zeros((4, 4))
tr[0:3, 0:3] = Mesh.rotation_matrix([0, 0, 1], 0.5 * numpy.pi)
tr[0:3, 3] = [1, 2, 3]
mesh.transform(tr)
assert numpy.allclose(mesh.vectors, numpy.array([
    [[0, 2, 4], [1, 3, 4], [1, 2, 4]]]))
assert numpy.allclose(mesh.areas, 0.5)
```


3.1 stl.Mesh

```
class stl.Mesh(data, calculate_normals=True, remove_empty_areas=False, re-
                move_duplicate_polygons=<RemoveDuplicates.NONE: 0>, name=u'', speedups=True,
                **kwargs)
```

Bases: `stl.stl.BaseStl`

areas

Mesh areas

attr

check()

classmethod debug(msg, *args, **kwargs)

Log a message with severity 'DEBUG' on the root logger.

dtype = dtype([('normals', '<f4', (3,)), ('vectors', '<f4', (3, 3)), ('attr', '<u2', (

classmethod error(msg, *args, **kwargs)

Log a message with severity 'ERROR' on the root logger.

classmethod exception(msg, *args, **kwargs)

Log a message with severity 'ERROR' on the root logger, with exception information.

classmethod from_file(filename, calculate_normals=True, fh=None,
 mode=<Mode.AUTOMATIC: 0>, speedups=True, **kwargs)

Load a mesh from a STL file

Parameters

- **filename** (*str*) – The file to load
- **calculate_normals** (*bool*) – Whether to update the normals
- **fh** (*file*) – The file handle to open
- ****kwargs** (*dict*) – The same as for `stl.mesh.Mesh`

classmethod from_multi_file (*filename*, *calculate_normals=True*, *fh=None*,
mode=<Mode.ASCII: 1>, *speedups=True*, ***kwargs*)

Load multiple meshes from a STL file

Parameters

- **filename** (*str*) – The file to load
- **calculate_normals** (*bool*) – Whether to update the normals
- **fh** (*file*) – The file handle to open
- ****kwargs** (*dict*) – The same as for *stl.mesh.Mesh*

get (*k*, *d*) → D[k] if k in D, else d. d defaults to None.

get_mass_properties ()

Evaluate and return a tuple with the following elements:

- the volume
- the position of the center of gravity (COG)
- the inertia matrix expressed at the COG

Documentation can be found here: <http://www.geometrictools.com/Documentation/PolyhedralMassProperties.pdf>

classmethod info (*msg*, **args*, ***kwargs*)

Log a message with severity ‘INFO’ on the root logger.

items () → list of D’s (key, value) pairs, as 2-tuples

iteritems () → an iterator over the (key, value) items of D

iterkeys () → an iterator over the keys of D

intervalues () → an iterator over the values of D

keys () → list of D’s keys

classmethod load (*fh*, *mode=<Mode.AUTOMATIC: 0>*, *speedups=True*)

Load Mesh from STL file

Automatically detects binary versus ascii STL files.

Parameters

- **fh** (*file*) – The file handle to open
- **mode** (*int*) – Automatically detect the filetype or force binary

classmethod log (*lvl*, *msg*, **args*, ***kwargs*)

Log ‘msg % args’ with the integer severity ‘level’ on the root logger.

logger = <logging.Logger object>

max_

Mesh maximum value

min_

Mesh minimum value

normals

points

classmethod remove_duplicate_polygons (*data*, *value=<RemoveDuplicates.SINGLE: 1>*)

classmethod `remove_empty_areas` (*data*)

rotate (*axis*, *theta*=0, *point*=None)

Rotate the matrix over the given axis by the given theta (angle)

Uses the `rotation_matrix()` in the background.

Note: Note that the *point* was accidentally inverted with the old version of the code. To get the old and incorrect behaviour simply pass *-point* instead of *point* or `-numpy.array(point)` if you're passing along an array.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.
- **point** (*numpy.array*) – Rotation point so manual translation is not required

rotate_using_matrix (*rotation_matrix*, *point*=None)

classmethod `rotation_matrix` (*axis*, *theta*)

Generate a rotation matrix to Rotate the matrix over the given axis by the given theta (angle)

Uses the [Euler-Rodrigues](#) formula for fast rotations.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.

save (*filename*, *fh*=None, *mode*=<Mode.AUTOMATIC: 0>, *update_normals*=True)

Save the STL to a (binary) file

If mode is AUTOMATIC an ASCII file will be written if the output is a TTY and a BINARY file otherwise.

Parameters

- **filename** (*str*) – The file to load
- **fh** (*file*) – The file handle to open
- **mode** (*int*) – The mode to write, default is AUTOMATIC.
- **update_normals** (*bool*) – Whether to update the normals

transform (*matrix*)

Transform the mesh with a rotation and a translation stored in a single 4x4 matrix

Parameters **matrix** (*numpy.array*) – Transform matrix with shape (4, 4), where matrix[0:3, 0:3] represents the rotation part of the transformation matrix[0:3, 3] represents the translation part of the transformation

translate (*translation*)

Translate the mesh in the three directions

Parameters **translation** (*numpy.array*) – Translation vector (x, y, z)

units

Mesh unit vectors

update_areas()
update_max()
update_min()
update_normals()
 Update the normals for all points
update_units()
v0
v1
v2
values() → list of D's values
vectors
classmethod warning(msg, *args, **kwargs)
 Log a message with severity 'WARNING' on the root logger.
x
y
z

3.2 stl.main module

stl.main.main()
stl.main.to_ascii()
stl.main.to_binary()

3.3 stl.base module

stl.base.AREA_SIZE_THRESHOLD = 0

When removing empty areas, remove areas that are smaller than this

class stl.base.BaseMesh(data, calculate_normals=True, remove_empty_areas=False, remove_duplicate_polygons=<RemoveDuplicates.NONE: 0>, name="u", speedups=True, **kwargs)

Bases: `python_utils.logger.Logged`, `_abcoll.Mapping`

Mesh object with easy access to the vectors through v0, v1 and v2. The normals, areas, min, max and units are calculated automatically.

Parameters

- **data** (*numpy.array*) – The data for this mesh
- **calculate_normals** (*bool*) – Whether to calculate the normals
- **remove_empty_areas** (*bool*) – Whether to remove triangles with 0 area (due to rounding errors for example)

Variables

- **name** (*str*) – Name of the solid, only exists in ASCII files
- **data** (*numpy.array*) – Data as *BaseMesh.dtype()*
- **points** (*numpy.array*) – All points (Nx9)
- **normals** (*numpy.array*) – Normals for this mesh, calculated automatically by default (Nx3)
- **vectors** (*numpy.array*) – Vectors in the mesh (Nx3x3)
- **attr** (*numpy.array*) – Attributes per vector (used by binary STL)
- **x** (*numpy.array*) – Points on the X axis by vertex (Nx3)
- **y** (*numpy.array*) – Points on the Y axis by vertex (Nx3)
- **z** (*numpy.array*) – Points on the Z axis by vertex (Nx3)
- **v0** (*numpy.array*) – Points in vector 0 (Nx3)
- **v1** (*numpy.array*) – Points in vector 1 (Nx3)
- **v2** (*numpy.array*) – Points in vector 2 (Nx3)

```
>>> data = numpy.zeros(10, dtype=BaseMesh.dtype)
>>> mesh = BaseMesh(data, remove_empty_areas=False)
>>> # Increment vector 0 item 0
>>> mesh.v0[0] += 1
>>> mesh.v1[0] += 2
```

```
>>> # Check item 0 (contains v0, v1 and v2)
>>> mesh[0]
array([1., 1., 1., 2., 2., 2., 0., 0., 0.], dtype=float32)
>>> mesh.vectors[0]
array([[1., 1., 1.],
       [2., 2., 2.],
       [0., 0., 0.]], dtype=float32)
>>> mesh.v0[0]
array([1., 1., 1.], dtype=float32)
>>> mesh.points[0]
array([1., 1., 1., 2., 2., 2., 0., 0., 0.], dtype=float32)
>>> mesh.data[0]
([0., 0., 0.], [[1., 1., 1.], [2., 2., 2.], [0., 0., 0.]], [0])
>>> mesh.x[0]
array([1., 2., 0.], dtype=float32)
```

```
>>> mesh[0] = 3
>>> mesh[0]
array([3., 3., 3., 3., 3., 3., 3., 3., 3.], dtype=float32)
```

```
>>> len(mesh) == len(list(mesh))
True
>>> (mesh.min_ < mesh.max_).all()
True
>>> mesh.update_normals()
>>> mesh.units.sum()
0.0
>>> mesh.v0[:] = mesh.v1[:] = mesh.v2[:] = 0
>>> mesh.points.sum()
0.0
```

```
>>> mesh.v0 = mesh.v1 = mesh.v2 = 0
>>> mesh.x = mesh.y = mesh.z = 0
```

```
>>> mesh.attr = 1
>>> (mesh.attr == 1).all()
True
```

```
>>> mesh.normals = 2
>>> (mesh.normals == 2).all()
True
```

```
>>> mesh.vectors = 3
>>> (mesh.vectors == 3).all()
True
```

```
>>> mesh.points = 4
>>> (mesh.points == 4).all()
True
```

areas

Mesh areas

attr

check()

classmethod debug (*msg, *args, **kwargs*)

Log a message with severity ‘DEBUG’ on the root logger.

dtype = **dtype**([('normals', '<f4', (3,)), ('vectors', '<f4', (3, 3)), ('attr', '<u2', (

- normals: `numpy.float32(), (3,)`
- vectors: `numpy.float32(), (3, 3)`
- attr: `numpy.uint16(), (1,)`

classmethod error (*msg, *args, **kwargs*)

Log a message with severity ‘ERROR’ on the root logger.

classmethod exception (*msg, *args, **kwargs*)

Log a message with severity ‘ERROR’ on the root logger, with exception information.

get (*k*, *d*) → *D*[*k*] if *k* in *D*, else *d*. *d* defaults to None.

get_mass_properties ()

Evaluate and return a tuple with the following elements:

- the volume
- the position of the center of gravity (COG)
- the inertia matrix expressed at the COG

Documentation can be found here: <http://www.geometrictools.com/Documentation/PolyhedralMassProperties.pdf>

classmethod info (*msg, *args, **kwargs*)

Log a message with severity ‘INFO’ on the root logger.

items () → list of *D*’s (key, value) pairs, as 2-tuples

iteritems () → an iterator over the (key, value) items of D

iterkeys () → an iterator over the keys of D

itervalues () → an iterator over the values of D

keys () → list of D's keys

classmethod log (*lvl, msg, *args, **kwargs*)
 Log 'msg % args' with the integer severity 'level' on the root logger.

logger = <logging.Logger object>

max_
 Mesh maximum value

min_
 Mesh minimum value

normals

points

classmethod remove_duplicate_polygons (*data, value=<RemoveDuplicates.SINGLE: 1>*)

classmethod remove_empty_areas (*data*)

rotate (*axis, theta=0, point=None*)
 Rotate the matrix over the given axis by the given theta (angle)
 Uses the [rotation_matrix\(\)](#) in the background.

Note: Note that the *point* was accidentally inverted with the old version of the code. To get the old and incorrect behaviour simply pass *-point* instead of *point* or *-numpy.array(point)* if you're passing along an array.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.
- **point** (*numpy.array*) – Rotation point so manual translation is not required

rotate_using_matrix (*rotation_matrix, point=None*)

classmethod rotation_matrix (*axis, theta*)

Generate a rotation matrix to Rotate the matrix over the given axis by the given theta (angle)

Uses the [Euler-Rodrigues](#) formula for fast rotations.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.

transform (*matrix*)

Transform the mesh with a rotation and a translation stored in a single 4x4 matrix

Parameters **matrix** (*numpy.array*) – Transform matrix with shape (4, 4), where matrix[0:3, 0:3] represents the rotation part of the transformation matrix[0:3, 3] represents the translation part of the transformation

translate (*translation*)

Translate the mesh in the three directions

Parameters **translation** (*numpy.array*) – Translation vector (x, y, z)

units

Mesh unit vectors

update_areas ()

update_max ()

update_min ()

update_normals ()

Update the normals for all points

update_units ()

v0

v1

v2

values () → list of D's values

vectors

classmethod warning (*msg, *args, **kwargs*)

Log a message with severity 'WARNING' on the root logger.

x

y

z

stl.base.DIMENSIONS = 3

Dimensions used in a vector

class stl.base.Dimension

Bases: *enum.IntEnum*

X = 0

X index (for example, *mesh.v0[0][X]*)

Y = 1

Y index (for example, *mesh.v0[0][Y]*)

Z = 2

Z index (for example, *mesh.v0[0][Z]*)

class stl.base.RemoveDuplicates

Bases: *enum.Enum*

Choose whether to remove no duplicates, leave only a single of the duplicates or remove all duplicates (leaving holes).

ALL = 2

NONE = 0

```

    SINGLE = 1
    stl.base.VECTORS = 3
    Vectors in a point
    stl.base.logged(class_)

```

3.4 stl.mesh module

```

class stl.mesh.Mesh(data, calculate_normals=True, remove_empty_areas=False, re-
    move_duplicate_polygons=<RemoveDuplicates.NONE: 0>, name="u",
    speedups=True, **kwargs)
Bases: stl.stl.BaseStl

areas
    Mesh areas

attr

check()

classmethod debug(msg, *args, **kwargs)
    Log a message with severity 'DEBUG' on the root logger.

dtype = dtype([('normals', '<f4', (3,)), ('vectors', '<f4', (3, 3)), ('attr', '<u2', (
classmethod error(msg, *args, **kwargs)
    Log a message with severity 'ERROR' on the root logger.

classmethod exception(msg, *args, **kwargs)
    Log a message with severity 'ERROR' on the root logger, with exception information.

classmethod from_file(filename, calculate_normals=True, fh=None,
    mode=<Mode.AUTOMATIC: 0>, speedups=True, **kwargs)
    Load a mesh from a STL file

    Parameters
    • filename (str) – The file to load
    • calculate_normals (bool) – Whether to update the normals
    • fh (file) – The file handle to open
    • **kwargs (dict) – The same as for stl.mesh.Mesh

classmethod from_multi_file(filename, calculate_normals=True, fh=None,
    mode=<Mode.ASCII: 1>, speedups=True, **kwargs)
    Load multiple meshes from a STL file

    Parameters
    • filename (str) – The file to load
    • calculate_normals (bool) – Whether to update the normals
    • fh (file) – The file handle to open
    • **kwargs (dict) – The same as for stl.mesh.Mesh

get(k[, d]) → D[k] if k in D, else d. d defaults to None.

get_mass_properties()

    Evaluate and return a tuple with the following elements:

```

- the volume
- the position of the center of gravity (COG)
- the inertia matrix expressed at the COG

Documentation can be found here: <http://www.geometrictools.com/Documentation/PolyhedralMassProperties.pdf>

classmethod info (*msg, *args, **kwargs*)

Log a message with severity 'INFO' on the root logger.

items () → list of D's (key, value) pairs, as 2-tuples

iteritems () → an iterator over the (key, value) items of D

iterkeys () → an iterator over the keys of D

itervalues () → an iterator over the values of D

keys () → list of D's keys

classmethod load (*fh, mode=<Mode.AUTOMATIC: 0>, speedups=True*)

Load Mesh from STL file

Automatically detects binary versus ascii STL files.

Parameters

- **fh** (*file*) – The file handle to open
- **mode** (*int*) – Automatically detect the filetype or force binary

classmethod log (*lvl, msg, *args, **kwargs*)

Log 'msg % args' with the integer severity 'level' on the root logger.

logger = <logging.Logger object>

max_

Mesh maximum value

min_

Mesh minimum value

normals

points

classmethod remove_duplicate_polygons (*data, value=<RemoveDuplicates.SINGLE: 1>*)

classmethod remove_empty_areas (*data*)

rotate (*axis, theta=0, point=None*)

Rotate the matrix over the given axis by the given theta (angle)

Uses the `rotation_matrix()` in the background.

Note: Note that the *point* was accidentally inverted with the old version of the code. To get the old and incorrect behaviour simply pass *-point* instead of *point* or *-numpy.array(point)* if you're passing along an array.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)

- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.
- **point** (*numpy.array*) – Rotation point so manual translation is not required

rotate_using_matrix (*rotation_matrix*, *point=None*)

classmethod rotation_matrix (*axis*, *theta*)

Generate a rotation matrix to Rotate the matrix over the given axis by the given theta (angle)

Uses the [Euler-Rodrigues](#) formula for fast rotations.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.

save (*filename*, *fh=None*, *mode=<Mode.AUTOMATIC: 0>*, *update_normals=True*)

Save the STL to a (binary) file

If mode is AUTOMATIC an ASCII file will be written if the output is a TTY and a BINARY file otherwise.

Parameters

- **filename** (*str*) – The file to load
- **fh** (*file*) – The file handle to open
- **mode** (*int*) – The mode to write, default is AUTOMATIC.
- **update_normals** (*bool*) – Whether to update the normals

transform (*matrix*)

Transform the mesh with a rotation and a translation stored in a single 4x4 matrix

Parameters matrix (*numpy.array*) – Transform matrix with shape (4, 4), where matrix[0:3, 0:3] represents the rotation part of the transformation matrix[0:3, 3] represents the translation part of the transformation

translate (*translation*)

Translate the mesh in the three directions

Parameters translation (*numpy.array*) – Translation vector (x, y, z)

units

Mesh unit vectors

update_areas ()

update_max ()

update_min ()

update_normals ()

Update the normals for all points

update_units ()

v0

v1

v2

values () → list of D's values

vectors

classmethod warning (*msg*, **args*, ***kwargs*)
Log a message with severity 'WARNING' on the root logger.

x

y

z

3.5 stl.stl module

stl.stl.BUFFER_SIZE = 4096

Amount of bytes to read while using buffered reading

class **stl.stl.BaseStl** (*data*, *calculate_normals=True*, *remove_empty_areas=False*, *remove_duplicate_polygons=<RemoveDuplicates.NONE: 0>*, *name=u"*,
speedups=True, ***kwargs*)

Bases: *stl.base.BaseMesh*

areas

Mesh areas

attr

check ()

classmethod debug (*msg*, **args*, ***kwargs*)
Log a message with severity 'DEBUG' on the root logger.

dtype = dtype (('normals', '<f4', (3,)), ('vectors', '<f4', (3, 3)), ('attr', '<u2', (

classmethod error (*msg*, **args*, ***kwargs*)
Log a message with severity 'ERROR' on the root logger.

classmethod exception (*msg*, **args*, ***kwargs*)
Log a message with severity 'ERROR' on the root logger, with exception information.

classmethod from_file (*filename*, *calculate_normals=True*, *fh=None*,
mode=<Mode.AUTOMATIC: 0>, *speedups=True*, ***kwargs*)
Load a mesh from a STL file

Parameters

- **filename** (*str*) – The file to load
- **calculate_normals** (*bool*) – Whether to update the normals
- **fh** (*file*) – The file handle to open
- ****kwargs** (*dict*) – The same as for *stl.mesh.Mesh*

classmethod from_multi_file (*filename*, *calculate_normals=True*, *fh=None*,
mode=<Mode.ASCII: 1>, *speedups=True*, ***kwargs*)
Load multiple meshes from a STL file

Parameters

- **filename** (*str*) – The file to load
- **calculate_normals** (*bool*) – Whether to update the normals
- **fh** (*file*) – The file handle to open

- ****kwargs** (*dict*) – The same as for *stl.mesh.Mesh*

get (*k*, *d*) → D[k] if k in D, else d. d defaults to None.

get_mass_properties ()

Evaluate and return a tuple with the following elements:

- the volume
- the position of the center of gravity (COG)
- the inertia matrix expressed at the COG

Documentation can be found here: <http://www.geometrictools.com/Documentation/PolyhedralMassProperties.pdf>

classmethod info (*msg*, **args*, ***kwargs*)

Log a message with severity 'INFO' on the root logger.

items () → list of D's (key, value) pairs, as 2-tuples

iteritems () → an iterator over the (key, value) items of D

iterkeys () → an iterator over the keys of D

itervalues () → an iterator over the values of D

keys () → list of D's keys

classmethod load (*fh*, *mode*=<Mode.AUTOMATIC: 0>, *speedups*=True)

Load Mesh from STL file

Automatically detects binary versus ascii STL files.

Parameters

- **fh** (*file*) – The file handle to open
- **mode** (*int*) – Automatically detect the filetype or force binary

classmethod log (*lvl*, *msg*, **args*, ***kwargs*)

Log 'msg % args' with the integer severity 'level' on the root logger.

logger = <logging.Logger object>

max_

Mesh maximum value

min_

Mesh minimum value

normals

points

classmethod remove_duplicate_polygons (*data*, *value*=<RemoveDuplicates.SINGLE: 1>)

classmethod remove_empty_areas (*data*)

rotate (*axis*, *theta*=0, *point*=None)

Rotate the matrix over the given axis by the given theta (angle)

Uses the *rotation_matrix()* in the background.

Note: Note that the *point* was accidentally inverted with the old version of the code. To get the old and incorrect behaviour simply pass *-point* instead of *point* or *-numpy.array(point)* if you're passing along an array.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.
- **point** (*numpy.array*) – Rotation point so manual translation is not required

rotate_using_matrix (*rotation_matrix*, *point=None*)

classmethod rotation_matrix (*axis*, *theta*)

Generate a rotation matrix to Rotate the matrix over the given axis by the given theta (angle)

Uses the [Euler-Rodrigues](#) formula for fast rotations.

Parameters

- **axis** (*numpy.array*) – Axis to rotate over (x, y, z)
- **theta** (*float*) – Rotation angle in radians, use *math.radians* to convert degrees to radians if needed.

save (*filename*, *fh=None*, *mode=<Mode.AUTOMATIC: 0>*, *update_normals=True*)

Save the STL to a (binary) file

If mode is AUTOMATIC an ASCII file will be written if the output is a TTY and a BINARY file otherwise.

Parameters

- **filename** (*str*) – The file to load
- **fh** (*file*) – The file handle to open
- **mode** (*int*) – The mode to write, default is AUTOMATIC.
- **update_normals** (*bool*) – Whether to update the normals

transform (*matrix*)

Transform the mesh with a rotation and a translation stored in a single 4x4 matrix

Parameters matrix (*numpy.array*) – Transform matrix with shape (4, 4), where matrix[0:3, 0:3] represents the rotation part of the transformation matrix[0:3, 3] represents the translation part of the transformation

translate (*translation*)

Translate the mesh in the three directions

Parameters translation (*numpy.array*) – Translation vector (x, y, z)

units

Mesh unit vectors

update_areas ()

update_max ()

update_min ()

```
update_normals ()
    Update the normals for all points

update_units ()

v0
v1
v2

values () → list of D's values

vectors

classmethod warning (msg, *args, **kwargs)
    Log a message with severity 'WARNING' on the root logger.

x
y
z

stl.stl.COUNT_SIZE = 4
    The amount of bytes in the count field

stl.stl.HEADER_SIZE = 80
    The amount of bytes in the header field

stl.stl.MAX_COUNT = 100000000.0
    The maximum amount of triangles we can read from binary files

class stl.stl.Mode
    Bases: enum.IntEnum

    ASCII = 1
        Force writing ASCII

    AUTOMATIC = 0
        Automatically detect whether the output is a TTY, if so, write ASCII otherwise write BINARY

    BINARY = 2
        Force writing BINARY
```


CHAPTER 4

Indices and tables

- `genindex`
- `modindex`
- `search`

S

- `stl.base`, 30
- `stl.main`, 30
- `stl.mesh`, 35
- `stl.stl`, 38

A

ALL (stl.base.RemoveDuplicates attribute), 34
AREA_SIZE_THRESHOLD (in module stl.base), 30
areas (stl.base.BaseMesh attribute), 32
areas (stl.Mesh attribute), 27
areas (stl.mesh.Mesh attribute), 35
areas (stl.stl.BaseStl attribute), 38
ASCII (stl.stl.Mode attribute), 41
attr (stl.base.BaseMesh attribute), 32
attr (stl.Mesh attribute), 27
attr (stl.mesh.Mesh attribute), 35
attr (stl.stl.BaseStl attribute), 38
AUTOMATIC (stl.stl.Mode attribute), 41

B

BaseMesh (class in stl.base), 30
BaseStl (class in stl.stl), 38
BINARY (stl.stl.Mode attribute), 41
BUFFER_SIZE (in module stl.stl), 38

C

check() (stl.base.BaseMesh method), 32
check() (stl.Mesh method), 27
check() (stl.mesh.Mesh method), 35
check() (stl.stl.BaseStl method), 38
COUNT_SIZE (in module stl.stl), 41

D

debug() (stl.base.BaseMesh class method), 32
debug() (stl.Mesh class method), 27
debug() (stl.mesh.Mesh class method), 35
debug() (stl.stl.BaseStl class method), 38
Dimension (class in stl.base), 34
DIMENSIONS (in module stl.base), 34
dtype (stl.base.BaseMesh attribute), 32
dtype (stl.Mesh attribute), 27
dtype (stl.mesh.Mesh attribute), 35
dtype (stl.stl.BaseStl attribute), 38

E

error() (stl.base.BaseMesh class method), 32
error() (stl.Mesh class method), 27
error() (stl.mesh.Mesh class method), 35
error() (stl.stl.BaseStl class method), 38
exception() (stl.base.BaseMesh class method), 32
exception() (stl.Mesh class method), 27
exception() (stl.mesh.Mesh class method), 35
exception() (stl.stl.BaseStl class method), 38

F

from_file() (stl.Mesh class method), 27
from_file() (stl.mesh.Mesh class method), 35
from_file() (stl.stl.BaseStl class method), 38
from_multi_file() (stl.Mesh class method), 27
from_multi_file() (stl.mesh.Mesh class method), 35
from_multi_file() (stl.stl.BaseStl class method), 38

G

get() (stl.base.BaseMesh method), 32
get() (stl.Mesh method), 28
get() (stl.mesh.Mesh method), 35
get() (stl.stl.BaseStl method), 39
get_mass_properties() (stl.base.BaseMesh method), 32
get_mass_properties() (stl.Mesh method), 28
get_mass_properties() (stl.mesh.Mesh method), 35
get_mass_properties() (stl.stl.BaseStl method), 39

H

HEADER_SIZE (in module stl.stl), 41

I

info() (stl.base.BaseMesh class method), 32
info() (stl.Mesh class method), 28
info() (stl.mesh.Mesh class method), 36
info() (stl.stl.BaseStl class method), 39
items() (stl.base.BaseMesh method), 32
items() (stl.Mesh method), 28
items() (stl.mesh.Mesh method), 36

items() (stl.stl.BaseStl method), 39
iteritems() (stl.base.BaseMesh method), 32
iteritems() (stl.Mesh method), 28
iteritems() (stl.mesh.Mesh method), 36
iteritems() (stl.stl.BaseStl method), 39
iterkeys() (stl.base.BaseMesh method), 33
iterkeys() (stl.Mesh method), 28
iterkeys() (stl.mesh.Mesh method), 36
iterkeys() (stl.stl.BaseStl method), 39
itervalues() (stl.base.BaseMesh method), 33
itervalues() (stl.Mesh method), 28
itervalues() (stl.mesh.Mesh method), 36
itervalues() (stl.stl.BaseStl method), 39

K

keys() (stl.base.BaseMesh method), 33
keys() (stl.Mesh method), 28
keys() (stl.mesh.Mesh method), 36
keys() (stl.stl.BaseStl method), 39

L

load() (stl.Mesh class method), 28
load() (stl.mesh.Mesh class method), 36
load() (stl.stl.BaseStl class method), 39
log() (stl.base.BaseMesh class method), 33
log() (stl.Mesh class method), 28
log() (stl.mesh.Mesh class method), 36
log() (stl.stl.BaseStl class method), 39
logged() (in module stl.base), 35
logger (stl.base.BaseMesh attribute), 33
logger (stl.Mesh attribute), 28
logger (stl.mesh.Mesh attribute), 36
logger (stl.stl.BaseStl attribute), 39

M

main() (in module stl.main), 30
max_ (stl.base.BaseMesh attribute), 33
max_ (stl.Mesh attribute), 28
max_ (stl.mesh.Mesh attribute), 36
max_ (stl.stl.BaseStl attribute), 39
MAX_COUNT (in module stl.stl), 41
Mesh (class in stl), 27
Mesh (class in stl.mesh), 35
min_ (stl.base.BaseMesh attribute), 33
min_ (stl.Mesh attribute), 28
min_ (stl.mesh.Mesh attribute), 36
min_ (stl.stl.BaseStl attribute), 39
Mode (class in stl.stl), 41

N

NONE (stl.base.RemoveDuplicates attribute), 34
normals (stl.base.BaseMesh attribute), 33
normals (stl.Mesh attribute), 28

normals (stl.mesh.Mesh attribute), 36
normals (stl.stl.BaseStl attribute), 39

P

points (stl.base.BaseMesh attribute), 33
points (stl.Mesh attribute), 28
points (stl.mesh.Mesh attribute), 36
points (stl.stl.BaseStl attribute), 39

R

remove_duplicate_polygons() (stl.base.BaseMesh class method), 33
remove_duplicate_polygons() (stl.Mesh class method), 28
remove_duplicate_polygons() (stl.mesh.Mesh class method), 36
remove_duplicate_polygons() (stl.stl.BaseStl class method), 39
remove_empty_areas() (stl.base.BaseMesh class method), 33
remove_empty_areas() (stl.Mesh class method), 28
remove_empty_areas() (stl.mesh.Mesh class method), 36
remove_empty_areas() (stl.stl.BaseStl class method), 39
RemoveDuplicates (class in stl.base), 34
rotate() (stl.base.BaseMesh method), 33
rotate() (stl.Mesh method), 29
rotate() (stl.mesh.Mesh method), 36
rotate() (stl.stl.BaseStl method), 39
rotate_using_matrix() (stl.base.BaseMesh method), 33
rotate_using_matrix() (stl.Mesh method), 29
rotate_using_matrix() (stl.mesh.Mesh method), 37
rotate_using_matrix() (stl.stl.BaseStl method), 40
rotation_matrix() (stl.base.BaseMesh class method), 33
rotation_matrix() (stl.Mesh class method), 29
rotation_matrix() (stl.mesh.Mesh class method), 37
rotation_matrix() (stl.stl.BaseStl class method), 40

S

save() (stl.Mesh method), 29
save() (stl.mesh.Mesh method), 37
save() (stl.stl.BaseStl method), 40
SINGLE (stl.base.RemoveDuplicates attribute), 34
stl.base (module), 30
stl.main (module), 30
stl.mesh (module), 35
stl.stl (module), 38

T

to_ascii() (in module stl.main), 30
to_binary() (in module stl.main), 30
transform() (stl.base.BaseMesh method), 33
transform() (stl.Mesh method), 29
transform() (stl.mesh.Mesh method), 37

transform() (stl.stl.BaseStl method), 40
 translate() (stl.base.BaseMesh method), 34
 translate() (stl.Mesh method), 29
 translate() (stl.mesh.Mesh method), 37
 translate() (stl.stl.BaseStl method), 40

U

units (stl.base.BaseMesh attribute), 34
 units (stl.Mesh attribute), 29
 units (stl.mesh.Mesh attribute), 37
 units (stl.stl.BaseStl attribute), 40
 update_areas() (stl.base.BaseMesh method), 34
 update_areas() (stl.Mesh method), 29
 update_areas() (stl.mesh.Mesh method), 37
 update_areas() (stl.stl.BaseStl method), 40
 update_max() (stl.base.BaseMesh method), 34
 update_max() (stl.Mesh method), 30
 update_max() (stl.mesh.Mesh method), 37
 update_max() (stl.stl.BaseStl method), 40
 update_min() (stl.base.BaseMesh method), 34
 update_min() (stl.Mesh method), 30
 update_min() (stl.mesh.Mesh method), 37
 update_min() (stl.stl.BaseStl method), 40
 update_normals() (stl.base.BaseMesh method), 34
 update_normals() (stl.Mesh method), 30
 update_normals() (stl.mesh.Mesh method), 37
 update_normals() (stl.stl.BaseStl method), 40
 update_units() (stl.base.BaseMesh method), 34
 update_units() (stl.Mesh method), 30
 update_units() (stl.mesh.Mesh method), 37
 update_units() (stl.stl.BaseStl method), 41

V

v0 (stl.base.BaseMesh attribute), 34
 v0 (stl.Mesh attribute), 30
 v0 (stl.mesh.Mesh attribute), 37
 v0 (stl.stl.BaseStl attribute), 41
 v1 (stl.base.BaseMesh attribute), 34
 v1 (stl.Mesh attribute), 30
 v1 (stl.mesh.Mesh attribute), 37
 v1 (stl.stl.BaseStl attribute), 41
 v2 (stl.base.BaseMesh attribute), 34
 v2 (stl.Mesh attribute), 30
 v2 (stl.mesh.Mesh attribute), 37
 v2 (stl.stl.BaseStl attribute), 41
 values() (stl.base.BaseMesh method), 34
 values() (stl.Mesh method), 30
 values() (stl.mesh.Mesh method), 37
 values() (stl.stl.BaseStl method), 41
 VECTORS (in module stl.base), 35
 vectors (stl.base.BaseMesh attribute), 34
 vectors (stl.Mesh attribute), 30
 vectors (stl.mesh.Mesh attribute), 37
 vectors (stl.stl.BaseStl attribute), 41

W

warning() (stl.base.BaseMesh class method), 34
 warning() (stl.Mesh class method), 30
 warning() (stl.mesh.Mesh class method), 38
 warning() (stl.stl.BaseStl class method), 41

X

x (stl.base.BaseMesh attribute), 34
 X (stl.base.Dimension attribute), 34
 x (stl.Mesh attribute), 30
 x (stl.mesh.Mesh attribute), 38
 x (stl.stl.BaseStl attribute), 41

Y

y (stl.base.BaseMesh attribute), 34
 Y (stl.base.Dimension attribute), 34
 y (stl.Mesh attribute), 30
 y (stl.mesh.Mesh attribute), 38
 y (stl.stl.BaseStl attribute), 41

Z

z (stl.base.BaseMesh attribute), 34
 Z (stl.base.Dimension attribute), 34
 z (stl.Mesh attribute), 30
 z (stl.mesh.Mesh attribute), 38
 z (stl.stl.BaseStl attribute), 41