CHAPTER 5

Surface Area, Volume, and Centroid of Mesh Objects

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5.1 INTRODUCTION

A three dimensional object is sometimes approximated by a mesh consisting a finite number of tetrahedra where, in this mesh, the surface of the object is approximated by a finite number of triangles (see an example in Figure 5.1). Here, we call the mesh as a mesh object.

Knowing some parameters related to the mesh object could be very useful to investigate many real problems of science and engineering (Crabb et al., 2014; Næss et al., 2017; Ledger et al., 2021). For example, if a complicated integration over a solid is solved numerically using the finite element methodology, the solid will be firstly approximated by a specified mesh. After that, numerical integration will be performed over the mesh. In this case, one might need to determine the surface area or the volume of each element in the mesh to compute the approximated integrals. For validation of the result, the total surface area or volume of all elements must respectively less than the surface area or volume of the solid.

On the other hand, evaluating the centroid of a mesh object is crucial for example in investigating the rotation of the three dimensional object represented by the mesh especially when the centroid of the object is not given (Ramlan, 2018). This

is necessary in order to obtain the correct rotation for the object as axes of rotation are actually related to the centroid. For instance, the standard rotation matrix describes rotation about the origin so, we have to make sure that the centroid of the object is at the origin before rotating the object using the standard rotation matrix.

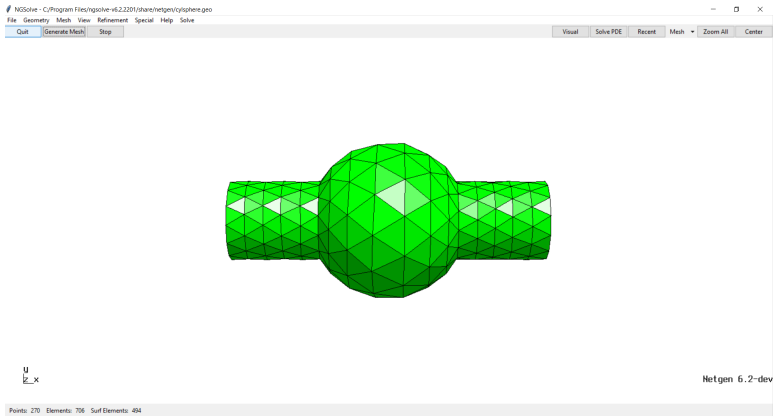

Figure 5.1 An example of a mesh object, generated by the software NETGEN and built from the combination of mesh for cylinders and sphere generated by the software NETGEN

Therefore, in this chapter, we will discuss about three parameters of a few mesh objects. They are surface area, volume and centroid of the mesh object. Besides, the other objective of this study is also to demonstrate simple examples of finite elements based on these computations. Besides promoting and encouraging finite elements, we hope the study can be a guideline for those who are new with finite elements. Now, in the next section, the construction of a mesh object from a three dimensional object will be discussed.

5.2 MODELLING GEOMETRY AS MESH OBJECT

In this study, the software NETGEN mesh generator is used to generate a mesh object. It is an open source powerful software developed by Joachim Schöberl at Johannes Kepler University Linz using C++ language and available for Unix, Linux, and Windows. The software generates mesh for an input of a three-dimensional object by partitioning the object into a set of finite elements such as tetrahedra and triangles (Schöberl, 1997). In solving engineering problems using finite element or finite volume, both methods require technique of partitioning an object into simple finite elements. In this case, the software is friendly to both methods as it provides object partitioning automatically. The software has been used to solve many problems in science and engineering. Specifically, the software has also been used in order to study on the polarization tensor and its application in electro-sensing fish and metal detection (Khairuddin and Lionheart, 2014; 2016; 2016a).

As the software is free, we have downloaded and installed NETGEN version 6.2 for the purpose of the study (a manual for NETGEN can be downloaded from. https://ngsolve.org/downloads) (Netgen/NGSolve, 2019). In order to generate a mesh, we have to load a geometry from a *.geo* file. On the software, this can be done by selecting the menu 'File' and then 'Load Geometry'. There are two folders that are provided by the developer, that is netgen and ngsolve folders for user. The package of the software includes *.geo* files is included in netgen folder for many objects such as sphere, ellipsoid, cube, cone and other geometries that we can use in order to find their meshes. Figure 5.2 shows the display of NETGEN after *cylsphere.geo* file is chosen as an example.