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Data Input Support System for Automatic Tetrahedral Mesh Generation Using Dynamic Bubble System

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***Abstract*— In this paper, a data input support system for automatic Tetrahedral (Tet) mesh generation using the dynamic bubble system [1] is presented. The dynamic bubble system has two processes: the first one is to generate nodes inside an analysis domain using the physically-based bubble system, and the second is to generate Tet finite elements according to the Delaunay algorithm. In the dynamic bubble system, the input data are the object shape and the radii of bubbles (vertex bubble) which are given at the object's vertex. However, the system, which is to input the data efficiently, has not been developed. Moreover it is difficult to determine the total number of nodes in the dynamic bubble system. By using the proposed support system, the input data can be easily prepared and the total number of nodes can be easily controlled. An example of mesh generation by the proposed system is presented.**

I. Introduction

To generate a mesh in the analysis domain is usually very laborious and time consuming, especially in 3-D space. A large number of methods for automatic mesh generation have already been proposed with various successes. It is well established that the ideas of mesh generation based on the Voronoi polygons and the Delaunay algorithm [2] are suited to finite element analysis (FEA) since these methods can minimize the maximum angle of elements. However, to generate the Delaunay meshes, we must place a set of nodes in the domain. This placement is not an easy task usually. Recently, we have developed and presented a very promising method for 3-D automatic Tet mesh generation based on the dynamic bubble system [1]. This method features; 1) a robustness, 2) a widely applicability, 3) a high quality of elements, 4) a graded dense mesh and 5) a small amount of input data. But it is difficult to generate a mesh of complicated model by the dynamic bubble system, because the system to prepare the input data has not been developed.

In this paper, the data input support system for the dynamic bubble system is presented. By using this system, we can prepare the radii of vertex bubbles and the material information easily, and the total number of nodes can be controlled. The control of the total number of nodes is necessary due to the limit of the usable computer memory. We explain the bubble System and its support system, and then its application is described.

II. Tet Mesh Generation Using Dynamic Bubble System

The dynamic bubble system [1] generates a set of bubbles and each bubble is defined with its radius, mass and position in the space according to its central coordinates. The movement of bubbles obeys the second Newton's Law of Dynamics and the acting forces based on the van der Waals forces between them. The input data of the dynamic bubble system are the object shape and the radii of bubbles which are given at the object's vertex.

The flow of the dynamic bubble system [1] is shown in Fig. 1. Firstly, a user sets bubbles on the vertices. Next, the generation of bubbles on the edges is performed, and then the movement according to the dynamic forces is performed. After the bubbles are generated on the faces of object, these bubbles move to stable state. Finally, the bubbles are generated inside the entire analysis domain and move. When the movement of all bubbles becomes stable, the center of each bubble is changed to nodes for the finite elements. Then a Tet finite element mesh is generated utilising the Delaunay algorithm.

III. Data Input Support System

In case of 3-D meshing, it is difficult to prepare even the object shape data. Therefore the object shape data can be made by a CAD software, and it is outputted by the DXF format which is adopted to exchange the object data between CADs. The input data, which are the radii of vertex bubbles, are prepared by using the system as shown in Fig. 2. This system equips functions in the following;

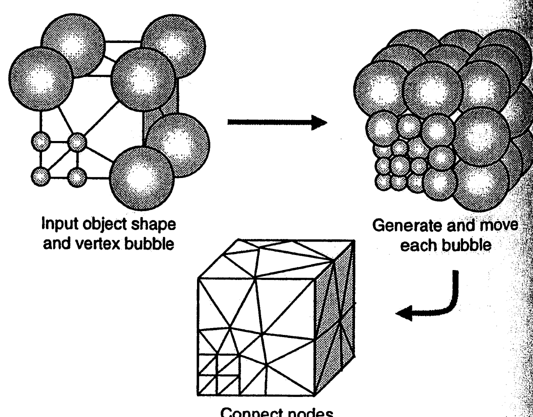

Fig. 1. Flow of dynamic bubble system.

- To decide radius of vertex bubble automatically.
- To change radius of vertex bubble.
- To input material information.
- To view of them.

These functions can be performed easily by using only a mouse. And we can also observe the 3-D object visually.

The automatic decision of the radius of vertex bubbles works as shown is Fig. 3. Generally, the vertices have to be dense in the area where the gradient of the physical value (the solution) is large. Hence, the radii of vertex bubbles have to be small. On the other hand, the vertices have to be coarse in the area where the gradient of the physical value is small. The radii of vertex bubbles have to be large. Therefore, firstly, the temporary radii of vertex bubbles are decided from the density of vertices. Next the bubbles are set temporarily on the edge, and the radius average r_{ave} of them is obtained. Next, the weight α is calculated using r_{ave} and N_0, which is the desired total number of nodes.

$$\alpha = \frac{1}{r_{ave}} \left(\frac{0.75 \times Volume}{\pi \times N_0} \right)^{\frac{1}{3}} \quad (1)$$

where, *Volume* is the total volume of the analysis domain. Then, $r_{default,i}$, which represents the vertex bubble's radius decided automatically, is obtained by multiplying the weight α and the temporary radius of bubble, r_i.

$$r_{default,i} = \alpha \times r_i \quad (2)$$

Using the function of the automatic decision of the radius of vertex bubble, the total number of nodes can be controlled easily.

IV. Applications

To verify the usefulness, the proposed system was applied to a model shown in Fig. 4. Fig. 4 (a) represents the model and the vertex bubbles visualised by the proposed system, and Fig. 4 (b) represents the subdivision map. The radii of vertex bubbles are decided by the function of the automatic decision in the proposed system. In this example, the total number of nodes is desired to be 1000. As a result, the number of nodes is 1313. We confirmed that this system could control the total number of nodes easily.

V. Conclusions

In this paper, a new data input support system using the dynamic bubble system is presented. In this system, we can prepare the input data easily, and can control the total number of nodes.

References

[1] T.Yokoyama et al., "3-D Automatic Mesh Generation for FEA using Dynamic Bubble System,", *IEEE Transaction on Magnetics*, Vol. 35, No. 3, pp.1318-1321, 1999.

[2] D.N.Shenton et al., "Three-Dimensional Finite Element Mesh Generation Using Delaunay Tessellation,", *IEEE Transaction on Magnetics*, Vol. 21, No. 6, pp.2535-2538, 1985.

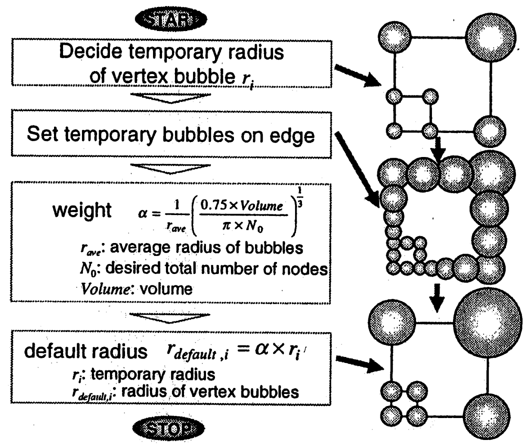

Fig. 3. Automatic decision of radius of vertex bubble.

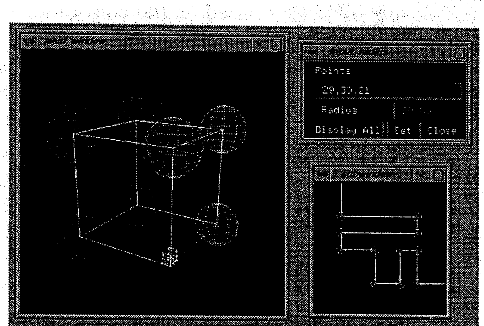

Fig. 2. Data input support system.

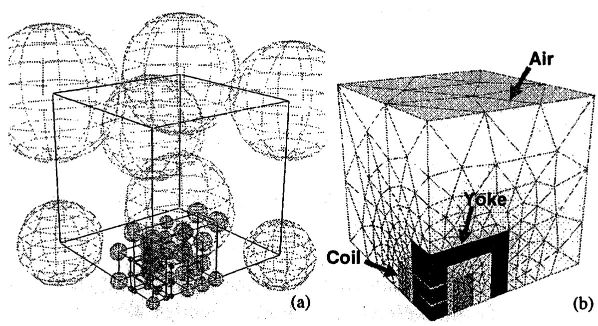

Fig. 4. Final Subdivision map: (a) input data (b) whole region.