REALISTIC HEXAGONAL FEM MESH GENERATING METHOD FROM BIOLOGICAL SOFT TISSUE

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INTRODUCTION

Our research is the development of the detached retinas operation simulator of the eyeball, which used FEM analysis.

The eyeball is composed of the soft tissue, which does the large deformation, and the thinnest part is 100μm. We have already developed the method (3D-ISM) of digitizing the internal structure of the eyeball in detail. The highest resolution obtained from this method is 1μm. A precise voxel model can be made based on this information. However, the element of the eyeball becomes one billion voxels in this voxel model. The finite element analysis cannot be done by this number of voxels. Then, the making method of the FEM mesh in which detailed shape information is reflected by a little number of elements is necessary. In this report on the method of generating the hexagonal FEM mesh from measured real continuously cross sectional dataset.

METHODS

The image obtained from 3D-ISM is a continuously full color cross sectional image. Fig.1 shows cross sectional image of pig eyeball. All of the data was 1000 images. It observation time was only 15minutes. These image resolution was 127μm and slice pitch was 30μm.

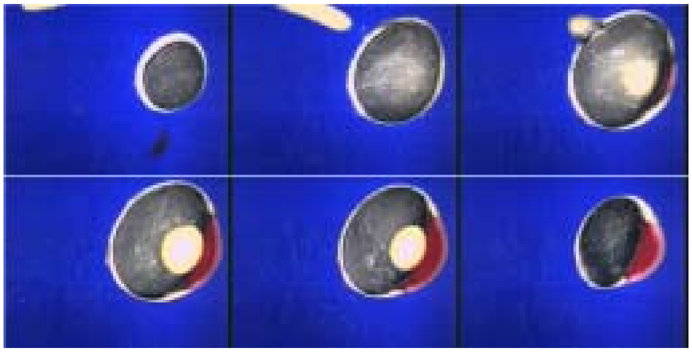

Fig.1 Cross sectional image of pi eyeball

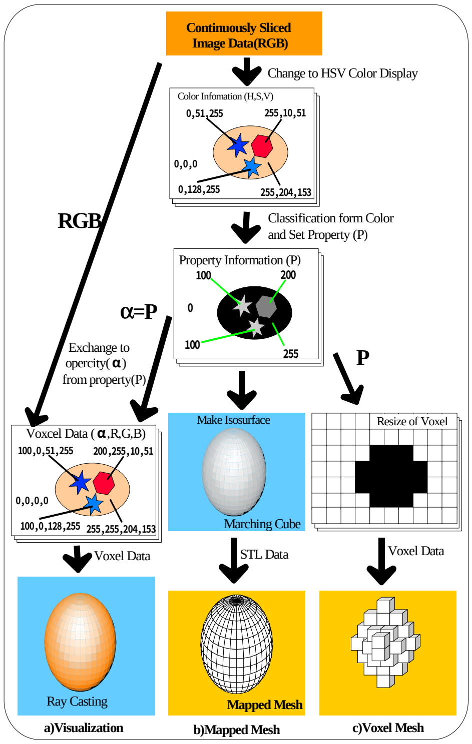

Fig.2 Flow Chart of Image Processing

Using the color information from this image to generates the hexagonal FEM mesh in the arbitrary part. Figure 2 shows the flow chart of processing. The part where the mesh generation is hoped is pulled out by using the color information. In the image pulled out, attribute information (P) is set to each pixel. To judge whether the extracted place is correct, the visualization is done. Information (a=P) on opacity is added to former picture data for the visualization.

Continuous section information made up is converted into voxel information. The reconstructed 3D image is made by using the Ray casting method (Figure. 2a). After the range of the extraction is set by the visualization, the FEM mesh is made. Information on the opacity set by the visualization is assumed to be attribute data of the object. The voxel data is made from attribute data (P) of a continuous section. The isosurface is pasted to the voxel data (Marching Cube method). The mesh is made by using the mapped mesh method (ICEM CFD/HEXA:ICEM Inc.) from surface information (Figure. 2b). The voxel mesh was made for the comparison (Figure. 2c). The voxel data is made as well as the isosurfaced mesh. The number of voxels is adjusted to the number of arbitrary, and the voxel data is made again (VOXCELCON: Quint).

RESULTS AND DISCUSSION

The object sample used a full-color continuously cross sections image of the pig eyeball, which had been taken a picture with 3D-ISM. The resolution of the image was XY: 127µm, Z: 90µm, and the size were 172x182x268 VOXEL. Figure 3a shows the 3D image of the visualized whole eyeball used the Ray casting. Figure 3b shows hexagonal FEM mesh generated with the Mapped mesh method. Almost the same externals forma as the 3D image of Figure 3b was shown. All the element points of contact are connected. Conversion from the attribute data to the STL data is 2 minutes, conversion into the FEM mesh is ten minutes. It was very high-speed and automatic. Figure 3c shows the voxel mesh. In the number of elements, in the mapped mesh is 14700 and the voxel mesh is 14296, there is almost same numbers. As for the shape of the mesh of the voxel model, because the ruggedness is large, the shape of the eyeball is not expressible. Fig.5 is a result of the cornea. They are same result of eyeball.

SUMMARY

The mesh in which actual shape of the soft tissue was reflected by "sequential image-segmentation-isosurface-mapped mesh" method was able to be made. Moreover, the same forma was able to be made from a little number of elements compared with the voxel mesh method. We think that this proposal is effective to generating the semi-automatic hexagonal mesh by which real shape is reflected.

REFERENCES

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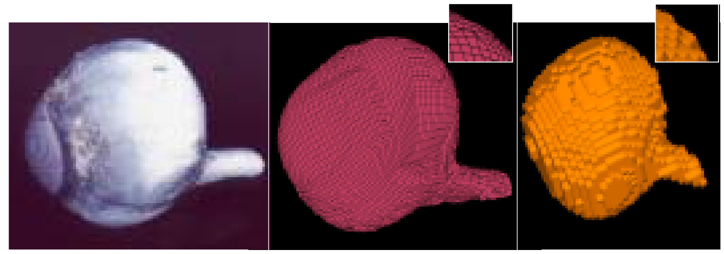
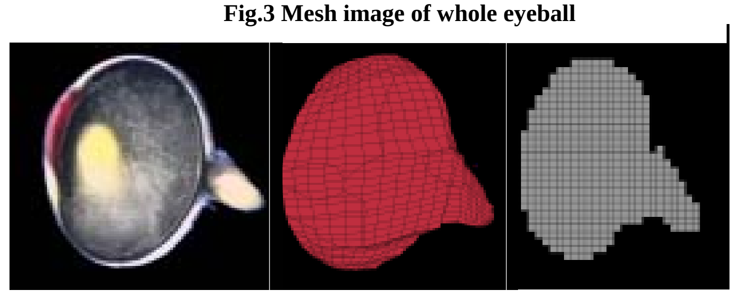


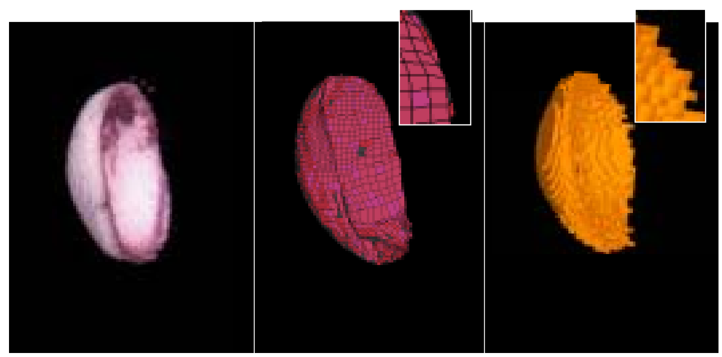
a. visualized b. mapped mesh c. voxel mesh

Fig.3 Mesh image of whole eyeball



a. visualized b. mapped mesh c. voxel mesh

Fig.4 Cross sectional image of whole eyeball



a. visualized b. mapped mesh c. voxel mesh

Fig.5 Mesh image of cornea