Metrics to evaluate the importance of features for the simplification of equipment 3D CAD assembly data

Soonjo Kwon *, Duhwan Mun**# and Soonhung Han*

* Department of Ocean Systems Engineering, KAIST, Korea
**Department of Precision Mechanical Engineering, Kyungpook National University, Korea
#*Corresponding author's E-mail address: dhmun@knu.ac.kr*

1. Introduction

Equipment 3D data take on different detail level depending on the purpose. Equipment supplier's CAD data have high complexity while plant engineering company needs CAD data with low complexity. Therefore, an automation tool supporting the simplification of equipment 3D CAD data is necessary.

2. 3D CAD data simplification methods

Conventional 3D CAD data simplification is characterized by the polygon-based method [1] and the feature-based method [2]. The polygon-based method has simpler input data structure and has less limitation to application. However, main dimensions may change during the simplification process. Due to this reason, the feature-based method was adopted in this study, For the simplification of 3D CAD data, a metrics should be developed to determine how important a feature is.

3. Simplification procedure of 3D CAD assembly

3D CAD assembly data of a supplier are delivered to a plant engineering company after the data processing shown in Fig. 1. The process involves port information extraction, specification data extraction, 3D CAD data simplification, and data merging, and data uploading steps.

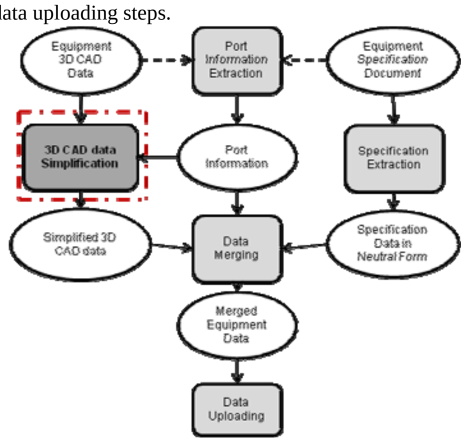

Fig. 1. Simplification procedure of 3D CAD assembly data

In the 3D CAD data simplification step, features in 3D CAD assembly are ranked by a predefined evaluation metrics and then are rearranged by rank. When a user inputs a target Level-Of-Detail (LOD), features with lower values are removed to achieve the target LOD.

4. Metrics to evaluate features in 3D CAD assembly

A metrics to evaluate features in 3D CAD assembly data is defined in Equation (1).

$$F_i = N_a^i * (P^i + C^i)$$
$$\text{where } P^i = P_a^i + P_b^i,$$
$$C^i = (w_a * C_a^i + w_b * C_b^i + w_c * C_c^i), \quad (1)$$
$$w_a + w_b + w_c = 1$$

The variable N_a^i is used to represent whether a feature F_i is to be deleted. If F_i is not visible from outside N_a^i is -1, otherwise 1. The variable N_a^i can be -1, or 1. The variable P^i is used to represent whether a feature F_i is to be preserved. If F_i is a port feature P_a^i = 1, otherwise 0. If F_i is an assembly constraint feature P_b^i = 2, otherwise 0. The variable P^i can be 0, 1, 2, or 3. The variable C^i is used to represent that a feature F_i is conditionally preserved. C_a^i is calculated by dividing the volume rank of a feature F_i by the total number of features. If a feature F_i is firstly connected to a port, C_b^i is 2/3; if a feature F_i is secondarily connected to a port, C_b^i is 1/3; otherwise 0. If a feature F_i is a bounding feature C_c^i is 1; otherwise 0. Different weights w_a, w_b, and w_c are given to three variables C_a^i, C_b^i, and C_c^i respectively. The variable C^i must be in the range of 0 to 1.

Experiment with a test case was conducted to demonstrate the feasibility of the proposed metrics. As shown in Fig. 2, simplification result can be adjusted by differentiating weights.

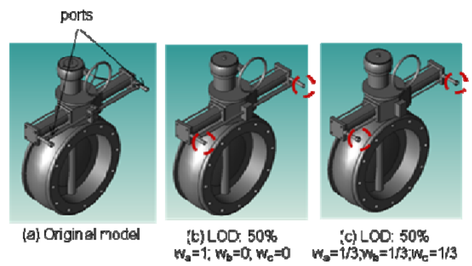

Fig. 2. Experiments with a test case (butterfly valve)

5. Conclusion

A new metrics is proposed to evaluate the importance of features for the simplification of 3D CAD assembly data. This metrics addresses simplification requirements specific to equipment 3D CAD data contrary to previous studies.

Acknowledgement

This research was supported by Industrial Strategic Technology Program of the Ministry of Knowledge Economy (project ID:10040162).

6. References

[1] Cignoni, P., Montani, C., Scopigno, R., "A Comparison of Mesh Simplification Algorithms", Computer & Graphics 22(1) (1998) pp.37-54.

[2] Lee, S.H., "Feature-based Multiresolution Modeling of Solids", ACM Transactions on Graphics 24(4) (2005) pp.1417-1441.