Title:
Evaluation of 3D Data Compression and Retrieval Method Based on Curve Mesh Filling

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Introduction:
Digital mock-up (DMU) and/or compound document with 3D data are one of the most important methods to represent a product model. Since 3D models become greater year by year, 3D data compression and retrieval algorithm is required to easily exchange such information through the internet. Because broadband is still not popular in some regions in the world, it is necessary to send huge data in a small size as much as possible.

A number of methods have been developed to compress 3D surface models; Wakita et al. [4] adopted surface interpolation method using Gregory patches [3]. However, the surface interpolation method cannot be applied to the concave shapes or shapes with holes. To overcome this problem, Muraki et al. proposed a surface compression method using a surface fitting method [1, 2]. In this paper, the performance of the 3D surface compression and retrieval algorithm based on a curve mesh interpolation [3] and N-side filling [1] is evaluated. To be more concrete, an application system that transfers 3D surface models has been firstly developed. After that, the performance is evaluated with different network environments: such as third generation of mobile telecommunications (3G) and Worldwide Interoperability for Microwave Access (WiMAX). As the result, we confirmed the effectiveness of our compression method with practical data.

Main idea:
The method proposed in this paper compresses the 3D surface model data. Fig.1 illustrates the main concept of our data compression and retrieval method. In our method, 3D surface type is classified to four elements; 1) Plane, 2) Interpolated surface, 3) Surface fitted with N-side filling method, and 4) other surface. Elements 1) to 3) are generated from the boundary edges by using our approach. Element 4) represents the complex trimmed surface which difficult to apply N-side filling method .The surface element is removed when the surface can be approximated within the tolerance. As the base surface of trimmed surface, contained in shape models, can be removed with this technique, it is possible to express the shape models with curve mesh representation. As a result, the amount of data is greatly reduced. The prediction function for the removed surface is added to the face as attribute information. The 3D shape model can be retrieved from the boundary curves with the prediction function.

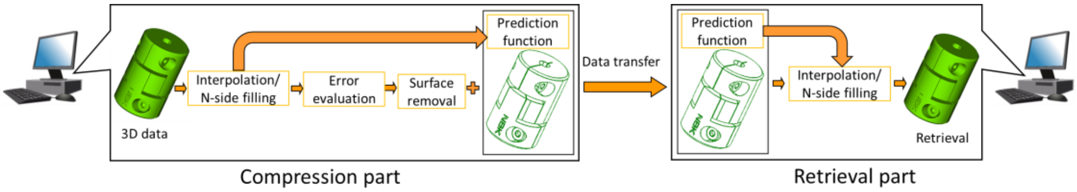
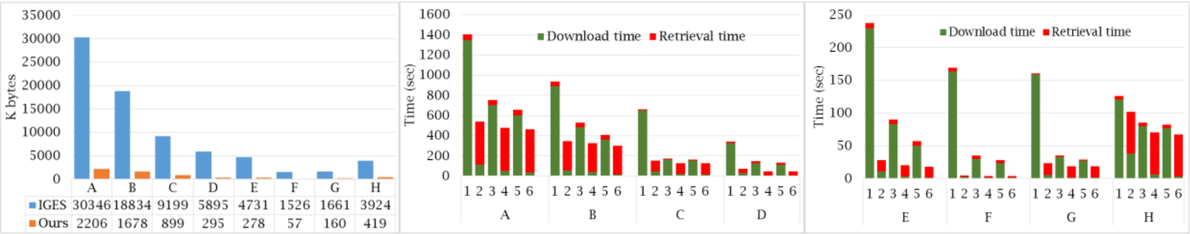


Fig. 1: Concept of 3D data compression and retrieval method.

Both our interpolation method and N-side filling method are difficult to apply to the composite surfaces. Therefore, a composite surface must be appropriately divided. After that surfaces are generated and evaluated with the tolerance. If this operation is acceptable, the original surface elements are removed. In our method, the surface element removal must be performed in the last stage of processing because the continuity of surfaces may collapse if it is performed in order. The compression stage of our method costs the calculation because the iterative calculations are required. For reducing the computational cost in the retrieval stage, some precalculated information is stored in the prediction function.



(a) (b) (c)

Fig. 2: From left to right: (a) comparison of data size of IGES data and ours, (b) and (c) show comparison of data transmission time for IGES data and ours, odd numbers represent IGES data and even ones represent our data. Pairs of 1 & 2, 3 & 4, and 5 & 6 are the results of transmission time for 3G, WiMAX 1.0Mbps and WiMAX 1.5Mbps respectively.

In data retrieval stage, the 3D surface model is retrieved from the boundary curves and the prediction function that is stored in the compression stage. In the compression stage, the error evaluation process is performed iteratively to make sure of the sufficiency of the generated surfaces. It is time consuming when the composite surface with the large number of control points is approximated, and the computational cost will be expensive. For avoiding these costs in the retrieval stage, it is necessary to add some practical information to the prediction function as attributes for generating surfaces. If the data size is reduced, the transmission time will be fast, but the retrieval cost will be high. For enhancing the time for retrieval, the precalculated information is used. To be more concrete, if the number of control points on approximated surfaces is more than a magical number N in the surface approximation process, the information that retrievals the surface is saved as the attributes. As the result, calculation cost of the surface generation can be reduced in the retrieval stage. Since the data size and calculation cost for retrieving surfaces are antinomy in each other, it is necessary to consider the balance of the data size and retrieval time by determining the added attributes with the number of surface control points.

Fig. 2 shows the comparison of data size and data transmission time by using our proposed method. In Fig. 2, A to H represents our test data. In Fig. 2(a)., the blue bars and orange ones represent IGES data and our data. we evaluated our transmission system by measuring the download time and retrieval time of compressed IGES data and our data with 3G, WiMAX 1.0Mbps and WiMAX 1.5Mbps. The unit of time is second. In Fig. 2(b) and Fig. 2(c), the green bars represent the download time and the red ones represent the retrieval time. Even though the retrieval time of our data is slower than the download time, overall performance of our data is faster than the IGES data. For example, in data F, the trasmission time of our data is approximately 39 times faster than that of the IGES data in 3G environments, approximately 10 times faster with WiMAX 1.0Mbps, and approximately 8 times faster than IGES data with WiMAX 1.5Mbps.

Conclusions:

In this paper, we evaluated our compression and retrieval method applying 3D surface models based on curve mesh interpolation method and N-side filling method. As a result, despite of the different terminal speeds of network environment, our system can exchange gigantic data to a smaller size in a shorter time.

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