A Prediction Model on 3D Model Compression and Its Printed Quality Based on Subjective Study

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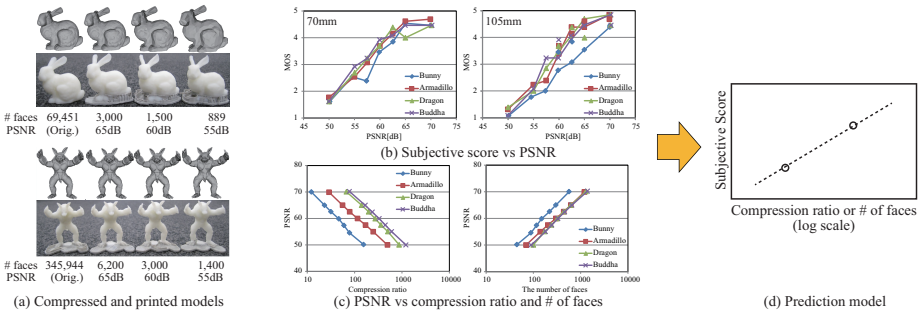

Figure 1: *A framework of our proposed quality prediction model.*

1 Introduction

3D printing is becoming a more common technology and has a growing number of applications. Although 3D compression algorithms have been studied in the computer graphics (CG) community for decades, the quality of the compressed 3D models are discussed only in the CG space. In this paper, we discuss the relationship between the PSNR of the compressed 3D models and the human perception to the printed objects. We conducted subjective evaluation by inviting 13 people and found that there is a clear linear relationship between them. Such a quality perception model is useful for estimating the printing quality of the compressed 3D models and deciding reasonable compression parameters.

2 Proposed model

Setup Armadillo, Bunny, Dragon, and Happy Budda, downloaded from The Stanford 3D Scanning Repository, were used. The numbers of faces, which correspond to the complexity of the models, were 345,944, 69,541, 871,306, and 1,087,474, respectively. The diagonal lengths of the bounding box were set to 70mm and 105mm to investigate the dependency on the model size. Then, all the models were compressed by using QEM [Garland and Heckbert 1997] so that the PSNR of the compressed models become 50–70dB. The PSNR of the compressed 3D models is defined as

$$PSNR = 10\log_{10}\left(\frac{BB^2}{\frac{1}{|S|}\sum_{p\in S} d(p,S')^2}\right), \qquad (1)$$

where BB is the bounding box diagonal, S and S' are the original and compressed models, respectively, and $|S|$ is the number of points on the model S. $d(p,S')^2$ is the distance between the point p and the closest point to p on the model S. The models were printed by Dimension bst768, whose minimum slice is 0.01 inches. The material was Acrylonitrile butadiene styrene (ABS).

Subjective evaluation and results Thirteen subjects (12 male and one female, 22-30 years old) participated in the evaluation. An original model and a randomly selected compressed model of the same character whose compression rate was unknown were given to the subjects. The subjects were allowed to do anything to the model (rotating, touching, etc.). The subjects were asked to evaluate the quality of the compressed model by the following subjective score: 5 (exactly the same) to 1 (completely different). The mean subjective scores are shown in Fig. 1. Clear linear relationships can be observed regardless of the complexity of the 3D models although it is well known that there is no linear relationship between the PSNR and subjective score in still image compression. It is also observed that the subjective scores get lower for larger models when compared at the same PSNR.

Prediction model To achieve the targeted PSNR, multiple try-and-errors are generally required. Therefore, we use a linear relationship between the PSNR and the number of faces, which is the parameter the user can specify. Namely, by compressing a 3D model with two different parameters, we can obtain a prediction model for the number of faces vs PSNR. Besides, by printing the compressed models and conducting the subjective evaluation, we can also obtain a subjective-score-to-PSNR model. As a result, we can predict the subjective score of the printed model from the number of faces of the compressed model. Such a model can be utilized for optimal compression parameter design. The model can also be used to discuss how much detailed representation is required because too much detailed 3D models would require a lot of strage space, processing time, and so on.

3 Conclusions

The quality of the compressed 3D model has been discussed only in the CG space. In this paper, we conducted a subjective study on PSNR of the compressed 3D models and their perceived subjective quality. We found that there is a linear relationship between them independent of the complexity of the 3D models. We also showed that there is a linear relationship between the number of faces and PSNR. By combining these two linear relationships, we proposed a quality estimation model for compressed 3D model printing.

References

GARLAND, M., AND HECKBERT, P. S. 1997. Surface simplification using quadric error metrics. In *SIGGRAPH*, 209–216.

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