Geometry-Aware Scattering Compensation for 3D Printing: Supplemental Document

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1 INTRODUCTION

In this supplemental material, we provide full-volume optimization reports (Section 2) and additional information on the comparison of the proposed full-3D method to a possible simple extension of the state-of-the-art work by Elek et al. [2017] referred to as the *2.5D method*. In Section 3, we describe our implementation of this extension. Then, in Section 4 we discuss the comparison of the results obtained with the 2.5D and proposed 3D methods.

2 FULL-VOLUME OPTIMIZATION REPORTS

Section 3.1 of the paper discusses a full-volume optimization for small test cases where finding a solution is feasible with a conjugate-gradient optimization. Alongside with this document we provide an archive with a collection of 27 optimization reports. A separate README-file in the archive describes the report layout.

3 REMAPPING OF PLANAR SLABS

In their work, Elek et al. [2017] presented a method for finding a scattering-compensated solution for fabrication of planar slabs with a texture. Their method can be extended to 3D by processing a texture in 2.5D and subsequently remapping this planar volume on a 3D mesh using the UV parametrization of the texture and the distance field of the voxelized object. Below we describe the exact procedure which we used for the conducted experiments.

A manual preprocessing pass on the UV mapping ensures as little stretch as possible and manifests enough margin between UV islands and to the border avoiding light bleeding between disconnected pieces. While rebaking the texture, these margins get filled by an inpainting algorithm. This benefits the planar scattering compensation by not introducing artificial color contrasts between UV covered regions and background, while also avoiding light in-scattering from the slabs boundaries.

Color distortions due to different orders of light scattering before and after the remapping are avoided by carefully selecting the slab's dimensions in the planar optimization. The lateral extent is scaled in a way that aligns texture-space distances with the corresponding distances on the final remapped object. So the extent in UV space of light scattering through the volume is kept constant during the remapping.

We optimize a slab with the preprocessed texture applied until the method described in [Elek et al. 2017] converges. The intermediate result, a 2.5D slab of RGB values, only needs to be warped into its final shape of the 3D surface to be ready for printing. This transformation uses the closest surface point mapping as described in our native 3D pipeline (see Section 5.1 of the paper). Additionally to texture color and normal, we also store the UV coordinate per surface voxel. When iterating over all inside voxels in a backwards-mapping fashion, we look up the corresponding surface voxel and its UV coordinate. The latter identifies the column (texel) on the 2.5D surface, while the distance to the former sets the lookup depth for the value stored at the current voxel. This way, conflicting columns

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This is a supplemental material.

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on convex surfaces are clipped to the maximum available depth of half the geometry thickness. Concave surfaces instead expand their columns in deeper layers. In the end, the resulting RGB 3D volume is halftoned for prediction or fabrication.

4 COMPARISON OF 2.5D AND 3D METHODS

Figure 1 presents the comparison of the 2.5D method to the proposed 3D method on all models used in the paper (Figure 14 in the paper). In this figure, columns (b) and (c) demonstrate rendered solutions obtained with the preview setup as described in Section 5.4 of the paper. Results of Our method in column (c) include all features described in the paper: full-3D processing, the new Update step, content-aware gamut-mapping.

As the 2.5D method operates on distorted object shape, the obtained results exhibit global and local artifacts. The red vase (row 2) and the cheetah-cat (row 3) are already discussed in Section 7.1 of the paper. We observe that the color of the red vase is over-saturated. The thin parts of the object (e.g., the hollow neck and basement of the red vase) feature unwanted blackening. The abdominal of the cheetah-cat has severe color shifts in the 2.5D solution. The yellow vase (row 1) is over-saturated in the case of 2.5D method, the predicted appearance does not match the target specification. These observations are supported by the CIEDE2000 metric values calculated on the renderings which are on average 1.5 times lower for the full-3D solution in comparison to the 2.5D method.

Comparing these three models to the existing solutions (GrabCAD, Cuttlefish in Figure 14 of the paper) we can conclude that the 2.5D method reproduces texture details better (local contrast); however, the uncontrolled introduction of artifacts makes the method unacceptable for general use.

The thin-geometry objects (rows 4–5) show that the 2.5D method achieves the level of quality of the existing solutions (GrabCAD, Cuttlefish); the visible cross-talk is comparable to them and significant. This is, in fact, not surprising as the 2.5D method operates under the assumption of a thick bulk of the material. The results obtained with the proposed 3D method demonstrate the significantly reduced cross-talk and the improved match to the target specification.

REFERENCES

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Fig. 1. Comparison on 5 target (a) models: (b) 2.5D method, the natural extension of [Elek et al. 2017], (c) Our scattering- and crosstalk-compensated solution. The last model is a thin planar slab of 0.5 mm thickness with two different textures on its front and back sides.