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Island-Preserving UV Transfer for Simplified Meshes

Suil Hwang
Department of Computer Science and Engineering
Hanyang University
Ansan, Republic of Korea
av600md@hanyang.ac.kr

Q Youn Hong
Department of Computer Science and Engineering
Hanyang University
Ansan, Republic of Korea
qhong83@hanyang.ac.kr

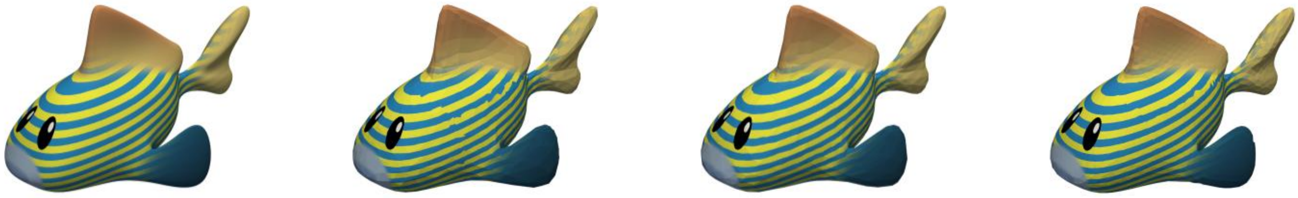

Fig. 1. Comparison of UV preservation methods on the Blub model simplified to approximately 1% of the original vertices. From left to right: original model, Garland and Heckbert [3], Liu et al. [6], and our UV transfer method applied to mesh simplified by CWF [2].

***Abstract*— On resource-constrained platforms like mobile and AR/VR, mesh simplification is essential for real-time rendering. Recent methods like CWF [2] achieve excellent geometric quality but ignore texture coordinates, limiting their use in textured models. We propose a post-processing method that transfers UV coordinates from original to simplified meshes. By detecting and preserving UV island structure, our method enables any geometric simplification to support textures. Results show that our method applied to simplified meshes achieves texture quality comparable to integrated methods.**

Keywords—Mesh simplification; UV transfer

I. Introduction

Mesh simplification is essential for rendering high-quality 3D content on resource-constrained platforms, such as mobile devices and AR/VR devices. Consolidating Weak Features (CWF) [2] preserves weak features during simplification to achieve excellent geometric quality. However, CWF critically lacks texture coordinate (UV) support, making them impractical for standard textured meshes. On the other hand, existing integrated methods [3, 4, 5, 6] that handle UVs sacrifice geometric quality due to UV continuity constraints, creating a trade-off between geometric accuracy and UV preservation.

We propose a post-processing method that transfers UVs from original meshes to meshes simplified by existing geometric methods, preserving the original UV island structure. Our main contributions are as follows:

- **UV Island Preservation.** We detect and maintain the structure of UV islands from the original mesh, preventing erroneous cross-island interpolation during transfer.
- **Island-Aware UV Transfer.** We ensure UVs are interpolated exclusively from faces within the same original island, thereby preserving texture continuity across the simplified mesh.

Our approach significantly enhances the practical utility of the existing mesh simplification methods, facilitating broader adoption in texture-critical applications.

II. Related Work

Quadric Error Metrics (QEM) [1] is the *de facto* standard for mesh simplification efficiently minimizing geometric error through edge collapse operations. Recently, CWF [2] inherited QEM's efficiency while preserving even weak features by combining normal anisotropy with the Centroidal Voronoi Tessellation (CVT) energy term. However, both methods rely solely on geometry without considering texture coordinates (UV), limiting their use in texture-critical applications.

Integrated approaches treat UVs during simplification: QEM was extended to handle appearance attributes [3, 4], appearance was preserved by measuring texture deviation [5], and seam-aware decimation techniques were proposed [6]. Alternatively, post-processing methods decouple UV computation from mesh simplification: attributes have been reconstructed onto a new texture atlas after simplification [7], reliable correspondence has been maintained via progressive map updates [8], and UV coordinates have been precisely recovered after remeshing [9]. In this work, we propose a post-processing method that preserves the original UV island structure, enabling accurate UV transfer.

III. Method

We propose a method to assign appropriate UV coordinates U_s to a simplified mesh $M_s = (V_s, F_s)$ given an original mesh

$M_o = (V_o, F_o, U_o)$, where V denotes the vertex set, F the face set, and U the UV coordinate set. As a preprocess, we compute the centroid $\mathbf{c}_i$ for each face $f_i \in F_o$.

A. UV Island Detection of the Original Mesh

A UV island is a maximal set of faces that are connected in the UV domain. We detect these UV islands in the original mesh M_o by finding connected components of faces that share UV vertices. We achieve this partitioning by defining an adjacency relationship between faces that share UV edges. We then traverse this structure using Breadth-First Search to identify all connected components, yielding the set of original islands:

$$\mathcal{I}_o = \{I_1, I_2, \dots, I_m\} \tag{1}$$

B. UV Transfer to the Simplified Mesh

To transfer UV coordinates while preserving texture continuity, we first assign each simplified face $f_s \in F_s$ to an original island. This inheritance is determined by finding the original face f_o^* whose centroid $\mathbf{c}_o$ is nearest to the centroid $\mathbf{c}_s$ of the simplified face:

$$f_o^* = \arg\min_{f_o \in F_o} |\mathbf{c}_s - \mathbf{c_o}|_2 \tag{2}$$

Next, we compute UV coordinates for the vertices of each simplified face f_s. The interpolation for all vertices of f_s is constrained exclusively to the set of original faces belonging to the island inherited by f_s. For each vertex $\mathbf{v}_s$ on f_s, we find the closest original face $f_{o,v}^*$ within this constrained set. The final UV coordinate $\mathbf{u}_s$ is then calculated via barycentric interpolation of the UVs from the vertices of $f_{o,v}^*$.

The resulting UV coordinates U_s, along with the inherited island indices for each face, provide the basis for reconstructing the final UV island in the simplified mesh.

C. UV Island Reconstruction of the Simplified Mesh

The final step is reconstructing islands on simplified mesh. Since simplification creates new adjacencies between faces from previously separate UV islands, using proximity in UV space to define connectivity is unreliable and can lead to incorrect island merging. Instead, we enforce consistency by connecting adjacent faces f_i and f_j only if they inherited the same original island index:

$$\text{connected}(f_i, f_j) = \begin{cases} 1 & \text{if } \mathcal{I}_0(f_i) = \mathcal{I}_0(f_j) \text{ and } \mathcal{I}_0(f_i) \neq -1 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

The final islands $\mathcal{I}_s$ are then formed by finding the connected components based on this rule.

IV. Results

To evaluate our method, we present a visual comparison using the Blub model simplified to approximately 1% of its original vertices. Figure 1 shows the rendering results of the original model, Garland and Heckbert [3], Liu et al. [6], and our UV transfer method applied to the mesh simplified by CWF [2].

Compared to Garland and Heckbert [3], our results exhibit noticeably less texture distortion. Despite not explicitly preserving UV seams during the simplification process as Liu et al. [6] do, our method achieves rendering quality comparable to theirs. We do observe some distortion near the original seam locations, which is an inherent limitation of post-processing approaches that reconstruct UV coordinates on already-simplified meshes. Nevertheless, our method offers significant practical value, as it can be combined with various mesh simplification algorithms, extending their applicability to textured models.

V. Conclusion

Our post-processing method enables recent geometric simplification methods to preserve texture quality through island-aware UV transfer. This decoupling preserves the full geometric quality of methods like CWF [2] while adding texture support without modifying their core algorithms. Our results show that using the original UV island structure as a guide produces renderings comparable to integrated methods. Island boundary distortions—our primary limitation—occur where UV seams meet simplified geometry, suggesting targeted improvements for these regions. Future work could extend this method to transfer additional material properties, further increasing its utility in production pipelines.

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