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Direct Geometric Texture Synthesis and Transfer on 3D Meshes

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Abstract

We present a technique for the transfer and synthesis of geometric texture on 3D surface meshes. Our technique combines localised surface fitting together with non-parametric sampling to facilitate the extraction, transfer and successful synthesis of geometric relief from one surface mesh to another.

1 Introduction

Geometric texturing uses localised 3D vertex displacements to represent surface texture in place of conventional 2D intensity based texture mapping. This allows the surface texture to be realistically re-lit from directional light sources and offers tactile interaction using haptic devices. Here we investigate *"geometric texturing by example"* - the transfer and synthesis of geometric texture from real surface meshes (*sample*), captured via 3D laser scanner, onto synthetically created surface meshes (*target*).

Prior work in this area is limited to solutions that utilise restrictive surface representations (voxels [1], geometry images [5]) rather than conventional meshes. By contrast we propose an approach that operates directly upon surface meshes using a two stage texture extraction and transfer/synthesis process.

2 Texture Extraction

We extract the geometric texture (localised surface relief) from the original surface mesh using localised surface fitting [4] to recover an orthogonal 3D displacement map for the sample surface.

Prior to extraction the sample and target surfaces are *vertex density correlated* to avoid the potential effects *geometric aliasing* on the later transfer/synthesis process [2]. This is performed by oversampling the lesser density of the pair (to an approximate equilibrium) via planar tessellation to avoid interfering with the Nyquist properties of the texture itself [2].

3 Texture Synthesis

Our geometric texture synthesis is based on an adaption of a non-parametric sampling approach [3] to 3D surface meshes. Initially, we copy a small seed patch of texture from our sample displacement map to the target surface. From this we grow the texture outwards, vertex-by-vertex, by iteratively propagating vertex displacement, from the sample, that is locally consistent with the textured vertex neighbourhood, $N(t)$, surrounding the current target vertex, t.

Local consistency is based on the rigid transformation and projection of the local vertex neighbourhood from the target surface, $N(t)'$, to every location, s, on the sample surface. A matching score for each is computed based to the weighed sum of squared projection distances (SSD) at each location [2]:

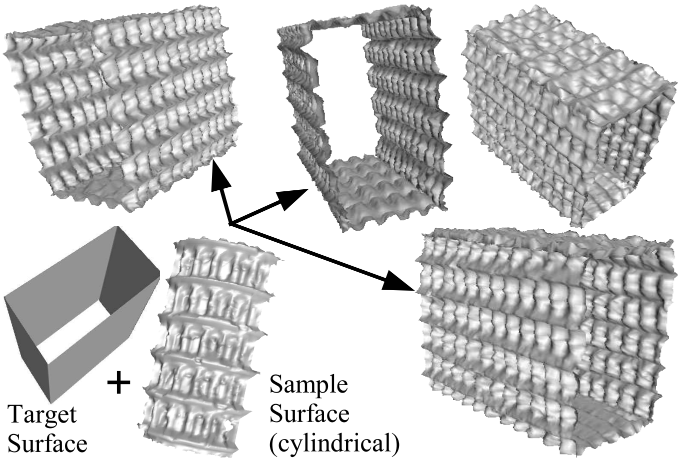

Figure 1: Transfer/synthesis of regular geometric texture

$$SSD = \sum_{s}^{v \in N(t)'} w_v \min_{\triangle \in triangles(s)} (dist(v, \triangle)^2) \qquad (1)$$

Texture diversity is maintained by stochastic selection from the top η% of matches found. *"Localness"*, the size of $N(t)$, is user defined by relation to the perceptual scale of texture features and rigid transformation is based on prior knowledge of a consistent orientation field for each surface - either user specified or constructed via an iterative convergence approach.

4 Results

To suitability illustrate the success of the approach, Figures 1 and 2 show the direct transfer of both regular architectural (1) and irregular natural (2) textures between differing surface meshes. The success of our approach is evident from both.

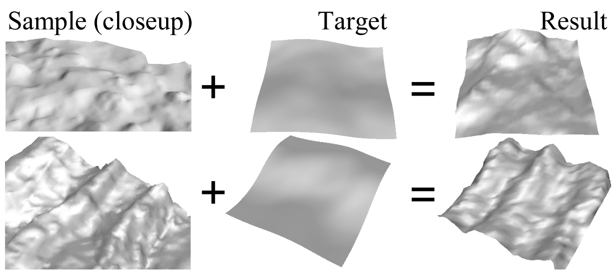

Figure 2: Texture transfer of regular/irregular texture

Future work: intelligent seeding, hierarchical surface meshes.

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