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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 weighted sum of squared projection distances (SSD) at each location [2]:

\[
SSD = \sum_s \min_{\Delta \in \text{triangles}(s)} \left( \text{dist}(v, \Delta)^2 \right)
\]

Texture diversity is maintained by stochastic selection from the top \( \eta \% \) 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.

Future work: intelligent seeding, hierarchical surface meshes.

References