Non-rigid Photometric Stereo with Colored Lights
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Key Idea
If a white object is illuminated by a red, a green and a blue light source, the color reflected by a point on the surface is in 1-1 correspondence with local orientation.

Illuminate the object with red, green and blue light from different non-coplanar directions. One color image simultaneously captures three images under different illumination.

Algorithm

Single frame from video
\[ [i_R \ i_G \ i_B]^T = L_{3x3} \cdot n \]

Color is converted to a normal at each pixel
\[ n = L_{3x3}^{-1} \cdot I \]

Normals integrated using SOR Poisson solver
\[ \Delta z = \nabla \cdot n \]

Optical flow
Adding a rigidity constraint improves registration over time
\[ E_R(T_i, \ldots, T_n) = \sum_{i=1}^{n} \| T_i - T' \| \]

Applications
Views of a single reconstructed frame at several angles (frontal, ±25°, ±50°)

Classic photometric stereo
Classic photometric stereo shot with a 4MPixel camera vs. our reconstruction of one frame of video. Average mesh distance is only 1.4% of the bounding box diagonal

Moving reconstructed cloth is soft-bound to an animated skeleton, “dressing” our avatar

Reconstructed meshes of a shirt flapping in the wind

Background
Un-textured deforming 3D objects are difficult to capture using surface features, structured light, or silhouettes.

Novelty
• Multi-spectral photometric stereo is an attractive alternative because it can recover a dense normal field from an un-textured surface.
• We show how to capture such video data and register it over time to generate a single deforming 3D surface.

Why this is important
• It is a simple and practical acquisition setup for acquiring high-detail, per-frame 3D reconstructions.
• Simple technique for capturing real moving cloth and ‘dressing’ a virtual character.