Shape-from-Shading under Near Point Lighting and Partial views for Orthopedic Endoscopy

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Abstract

Bone reconstruction using endoscopy is important for computer aided minimally invasive orthopedic surgery. During surgery an endoscope consisting of a camera and one or more light sources is inserted through a small incision into the body and the acquired images are analyzed. Since bone surface is featureless, shading is the primary cue for shape perception. However, due to the small field of view of the endoscope, only a small part of the bone and its occluding contour are visible in any single image. Therefore even human perception of bone shape from such images can be hard.

We present a novel technique to reconstruct the surface of the bone by applying shape-from-shading to a sequence of endoscopic images, with partial boundary in each image. We first perform geometric and the photometric calibration for the endoscope. We then extend the classical shape-fromshading algorithm to include a near point light source that is not optically co-located with the camera. By tracking the endoscope we are able to align partial shapes obtained from different images in the global (world) coordinates. An ICP algorithm is then used to improve the matching, resulting in a complete occluding boundary of the bone. Finally, a complete and consistent shape is obtained by simultaneously re-growing surface normals and depths in all views. We demonstrate the accuracy of our technique using simulations and experiments with artificial bones.

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