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Exploiting Occlusion Detection and Modelling in Multi-view 3-D Shape Reconstruction

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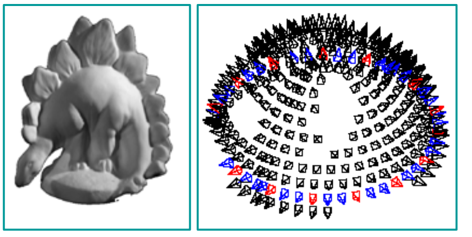
Objectives

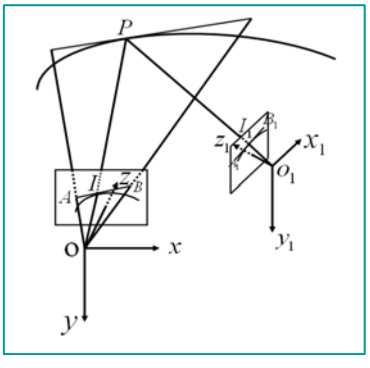
One of the fundamental steps in addressing multi-view 3D shape reconstruction is to establish the correspondence across different views of image regions belonging to the same 3D object. Typically, the correspondence between two regions is obtained by selecting patterns with the smallest discrepancy under the normalised cross-correlation criterion. Such correspondence however, can be established only at regions where the surface can be locally approximated by a plane. This is never satisfied at occlusions, where the surface undergoes a sharp discontinuity. At such locations we suggest to establish correspondence by exploiting the geometry of surfaces and the camera system. This leads to a novel correspondence criterion that enhances the accuracy and robustness of any multi-view reconstruction algorithm. We demonstrate some preliminary results on data available from the Middlebury dataset.



Left: 1 of the 363 input images. Right: the cameras configuration (a hemisphere).

Methodology

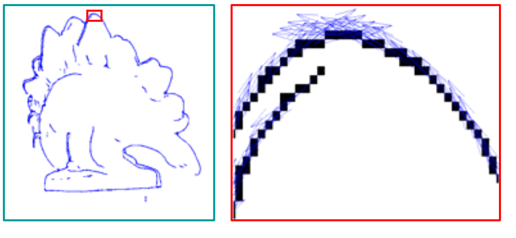
Building correspondence using edges



To establish the correspondence between points at occlusions, we make use of the so-called *frontier points*. Frontier points are intrinsically defined by the position of two cameras and a point on the surface. With reference to the figure to the left, consider a plane passing through the two camera centers and tangent to the object at a point P. The point P just defined is a frontier point and it projects onto two cameras at coordinates I and I_1. The smooth surface below P projects onto the image planes and generates an occlusion boundary with the projection of the background. These two occlusion boundaries are related to each other as both tangent vectors at I and I_1 lie on the plane formed by the two camera centers and the point P. The main property of frontier points is that one can estimate their position by establishing correspondence between the tangents at the occluding edges in each image. Also, these points automatically define the normal to the surface via the camera centers.

Edge detection and tangent direction extraction

To identify frontier points, the first step is to determine the occlusion boundaries. This can be achieved in several ways, and a simple approach is to look at edges. We detect edges by finding the maxima of the L_1 norm of the gradient of each intensity image. The left image of the figure on the right shows the edges detected on an input image. The second step is to estimate the tangent vectors at each point on the edge. We do so by filtering the gradient at the edge locations. The right image on the figure to the right shows a magnified detail where one can appreciate the estimated tangent vectors.



Left: Detected edges. Right: Magnified detail from the left with estimated tangent vectors.

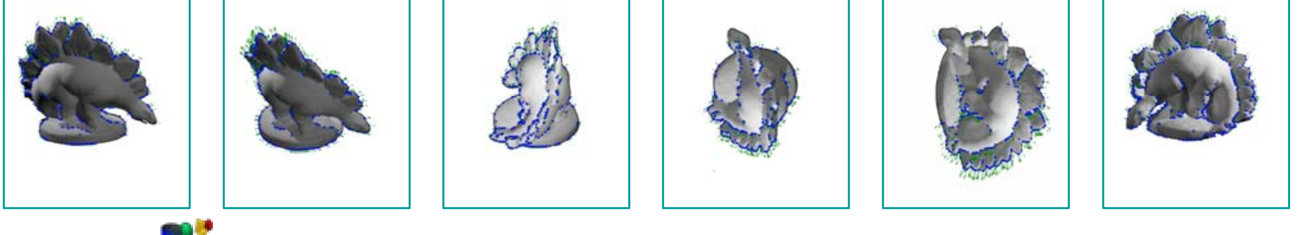
Frontier point correspondence algorithm

To estimate the position of a point P at an occluding boundary, we can use two matching terms: one term measures the distance Φ between the projection of P on the image plane of camera j and the edge map on that camera, and the second term measures the discrepancy Ψ between the tangent vector at I_j and the plane OAB

$$\hat{P} = \arg\min_{P} \sum_{j} \Phi\left(I_j(P), E_j\right) + \Psi\left(T_j(P), \overline{OAB}\right)$$

Preliminary Results on Real Data

The images below show results on real data available on the Middlebury database. We show 6 of the input images where we superimposed the estimated frontier points and the corresponding surface normals (up to the s



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