3D Reconstruction from Images taken with a Coaxial Camera Rig

Estimating dense depth maps from image pairs taken along the same optical axis is a special case of multiple-view geometry. The coaxial camera rig (cameras that image along the same optical axis via a beam-splitter), a forward translating camera, and a depth from zooming camera all fall in this category. This type of multi-view imaging has advantages over traditional binocular stereo because occlusions are nearly eliminated and the baseline can be folded inside the camera to create small form factors with large baselines. This later characteristic permits 3D reconstruction from coaxial images taken through a bore-scope or endoscope. The method, however, has not found wide acceptance because of the "unrecoverable point" problem, which refers to the central area of image pairs where the disparity is too small to recover depth using pixel intensities or features based correspondences.

We introduce a novel automated method using variational methods for resolving the unrecoverable point problem by finding correspondences using the optical flow fields. In applications where there is motion between the camera rig and the scene (bore-scopes and endoscopes) and where the scene exhibits visual texture, our method produces accurate dense depth maps.

We test our method on synthetic optical flow fields and on real image sequences taken with a coaxial camera rig. We demonstrate our method's accuracy by comparing against a precision ground-truth. Results are comparable to a traditional binocular stereo camera rig, but without the need for the traditional stereo baseline and with substantially smaller occlusions.