

Surface Reconstruction from Feature Based Stereo

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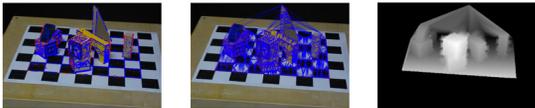
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Objective:

- Recover surface models for complex scenes from the quasi-sparse data returned by a feature based stereo system.

Reasoning About Scene Structure:

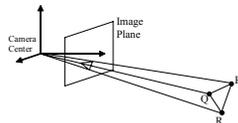
- We assume that the scene can be approximated by a collection of planar patches whose vertices correspond to features in the images.
- For scenes with this property, we can *approximate* the disparity map in each stereo pair by triangulating the features recovered with that baseline. These triangulated disparity maps can contain errors, **however, they correctly predict freespace when all of the visible features are recovered.**



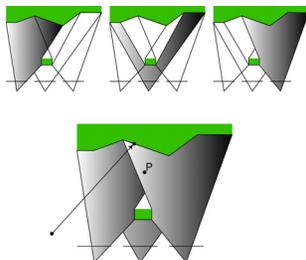
Recovered features Triangulation Interpolated disparity

Freespace Theorem:

- If the feature points p , q and r form a Delaunay triangle in a given image then the tetrahedron formed by the camera center and the corresponding 3D points P , Q and R consists entirely of freespace. (Jelinek, Taylor ECCV '02)

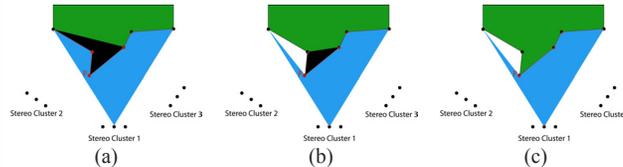


- We can reason about the structure of space by considering the **union** of the freespace volumes induced by a collection of triangulated disparity maps.



Handling Missing Features:

- A naïve application of the Freespace Theorem can fail in the presence of interpolation artifacts caused by missing data points as illustrated below.

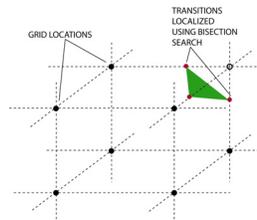


- The feature labeled P is not recovered by stereo cluster 1. The freespace volume obtained by triangulating the remaining points in that view will eliminate a significant portion of the surface
- Simply adding feature points reconstructed from other viewpoints and re-triangulating does not fix the problem.
- The problem can be overcome by adding the points to the triangulation *incrementally* based on their height above the current triangulated surface.

- In 3D, this correction is accomplished by modifying an incremental Delaunay triangulation scheme. The red feature points on the image in the previous column were added to the triangulated disparity map from other stereo views using this scheme.
- The observation that the freespace volume cannot contain any of the recovered feature points is termed the *minimum disparity constraint*.

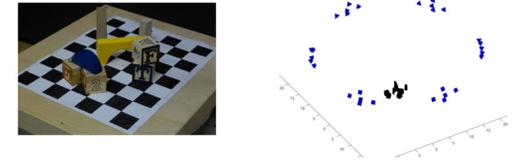
Recovering Surfaces:

- An indicator function, $\Phi(P)$, which provides an *implicit* approximation of the freespace can be computed easily from the triangulated disparity maps.
- A variant of marching cubes can be applied to this function to recover a surface mesh.
- Transitions between grid sample points can be accurately localized using bisection search.

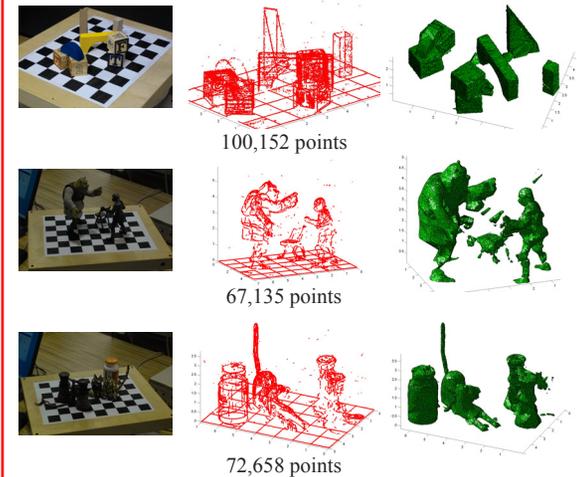


Experimental Setup:

- Six clusters of five images were taken at evenly spaced intervals around the scene.



Experimental Results:



Conclusions:

- It may be more appropriate to view stereo reconstructions as providing information about the *freespace* in the scene rather than measurements of surface structure.
- One can overcome errors in individual stereo results by carefully combining results from multiple views.
- It is possible to recover a great deal about the structure of space from surprisingly few correspondences

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