Local 3D Model Verification and Refinement

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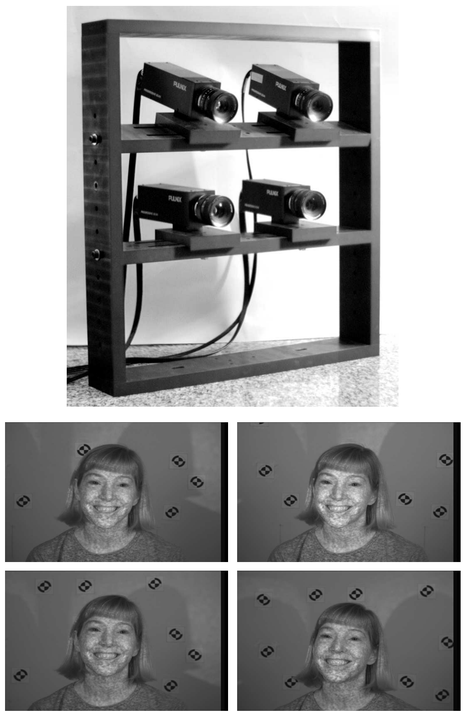


Input images

3D Geometric Reconstruction using Fish-Scales

1. Isolated points reconstructed from stereo.

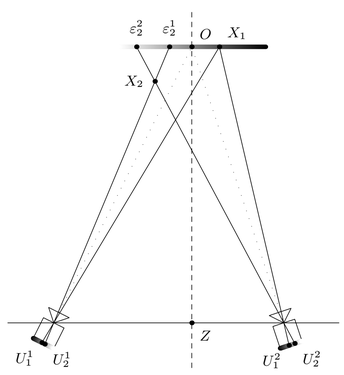
2. Fish-Scales (F-S) are semi-local disks recovered from 1.

3. Triangulated surface by bottom-up process from 2.

4. Surface with real texture.

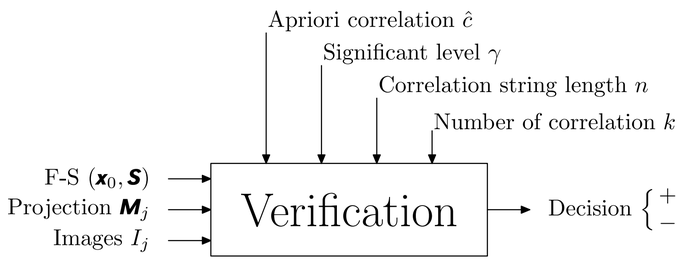
Fish-Scales Verification

Verification ≡ extraction of the F-S, which are not consistent with images.



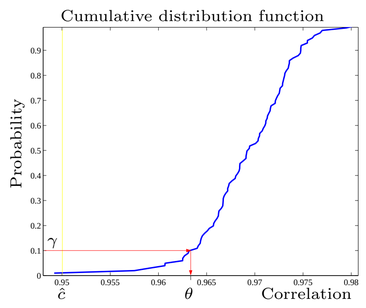
Legend:

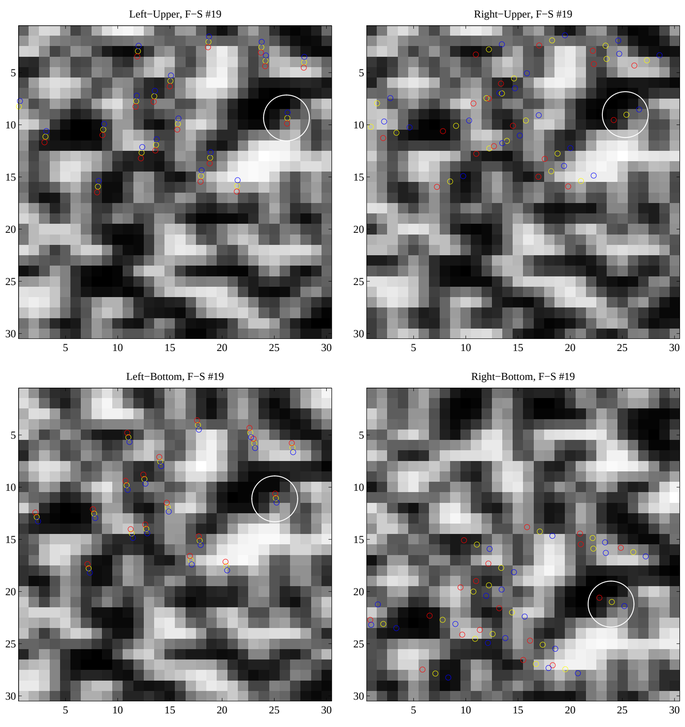
- consistent point;
- 2 mm towards,
- out of camera.



Algorithm:

1. Distribution.
2. Statistical test.
3. Decision $\hat{c} < \theta$.





Measures of consistency:

1. Sum of square differencies.
2. Standard correlation (linear invariant).
3. Rank correlation (known distribution).

F-S Refinement

Refinement ≡ changes values of F-S parameters to make F-S more consistent.

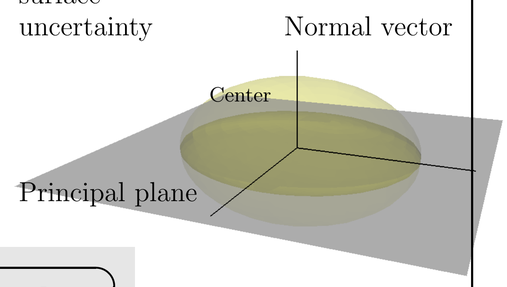
Optimization technique is used for both movement along the F-S normal vector and orientation of the normal vector.

Fish-Scale

F-S parameters:

- **center** $\boldsymbol{x}_0$–fish-scale position in 3D space
- **structure matrix** $\boldsymbol{S}$ –orientation, 'radii', and local surface uncertainty

Two f-s with different surface uncertainty



Results

References

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[2] Vít Zýka. Recovering accurate geometric surface model from passive stereo vision. Technical Report K335-98-153, ČVUT FEL, dep. of Control Engineering, Praha, Czech Republic, January 1998. Thesis proposal.

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Abstract:

This work deals with verification and refinement of semi-local 3D geometric model recovered from noisy data obtained by stereo vision. This, so called Fish-Scale (F-S) model, forms an intermediate representation in the bottom-up process of complete triangulated surface model reconstruction from unorganized isolated points in 3D space. The F-S model consists of independent primitives that resemble small disks. Our concern is that, due to stereo algorithm failures and/or unrealistic a priori assumptions about the scene properties, some fish-scale parameters (location, orientation) may be biased. We have two goals: First, to verify whether the models (taken as hypotheses) are still consistent with original image data and eliminate those that are not. Second, to refine models in terms of finding parameter update that maximizes consistency with image data.

To assess the consistency, fish-scales are re-projected back to images and the corresponding image regions are compared. If the fish-scales position and orientation estimates are biased, the images will not be images of the same physical object and they will not be mutually congruent. This congruence can be assessed by standard statistical methods.

In the verification part the following issues show up. First, the images of the same object point are not identical in value because of the spatial anisotropy of surface reflectance. Second, simple correlation measures have distribution that depends on the distribution of the random variables. The latter issue is more severe given the enormous variability of real-world images. To alleviate both problems we decided on rank correlation. The verification then compares the correlation value against a threshold selected as an upper percentile of the correlation function distribution.

For the model refinement the standard correlation is used for optimizing of consistency instead of rank correlation. Correlation guarantees normalization of data from different images. In this case, a rank measure is not needed for two reasons. First, ranks make the correlation function less smooth and consequently less suitable for maximum search. Second, no threshold is to be chosen so no known distribution of consistency function is required.

Good statistical decision allows for elimination of local models that are likely not to correspond to real objects, which significantly improves the performance of the next step in global 3D model reconstruction. The influence of fish-scales refinement to the final fidelity of geometric model is obvious.

Our reconstruction method is demonstrated on human face geometric model reconstruction. For both the fish-scales verification and refinement processes, at least three images are required. We use up to four images to make the verification more reliable.