Affine Structure from motion

**#### Abstract**

The structure-from-motion problem is to infer the structure of these spatial configurations from the sequence of projections.

**### Introuduction**

A "view" is a central projection, i.e., the points are mapped on a pencil of concurrent visual rays. Their common inter- section is the center of projection or vantage point. The N vantage points are again assumed to be in general position. "General position" means that slight perturbations of the configurations of N vantage points and M fiducial points will not lead to qualitative changes in a possible solution.

**In this paper we address only a slightly simplified form of the problem, namely, we restrict the discussion to orthographic projections.**

**### STRATIFICATION OF THE STRUCTURE-FROM- MOTION PROBLEM**

In this paper we skip the front end of the stratification.We also require the ability to perform affine operations.Clearly, the stratification could be pushed much further than we do in the present paper.We merely indicate some layers that appear to be especially useful in view of the given problems.

In addition, we limit the discussion to the case of parallel projection, or the case of a restricted field of view and simultaneously restricted depth range.This limitation makes pratical sense for two reasons:

1.Parallel projection is a good approximation to central projection if the field of view is small and the depth range restricted.

2.Arbitrary smooth deformations are locally equivalent to affine transformations.

**### AFFINE STRUCTURE-FROM-MOTION THEOREM**

This is sufficient to enable you to predict outlines for arbitrary viewing directions (viewing direction specified in terms of the frame, projection predicted modulo an affine transformation), the equiluminance contours for a given di- rection of light source (idem), and so forth. Although the affine solution does not permit predictions of a metrical nature, it is a true three-dimensional entity in the sense that it allows you to predict arbitrary views.

**### NUMERICAL EXPERIMENT**

t is a straightforward exercise to implement the affine stage numerically. You need a routine that enables you to find the imagebofavectora,say,under an affinetransformation that carries the pair of vectors f 2 into the pair g1,2. This is a problem in linear algebra.

We have studied cases including nonrigid transforma- tions. The results are equally good. Rigidity is absolutely irrelevant to the affine structure-from-motion problem. Studies with randomly perturbed views reveal that this type of solution is rather robust.

**### RIGIDITY AND THE METRIC**

Until now we have used only affine properties: bisection of line segments or the ability to draw a line parallel to a given line through a given point, and the ability to find the ratio of lengths of parallel line segments. Additional structure can be computed if you permit metrical concepts.

In this paper we introduce metrical concepts and the rigid- ity hypothesis at the same stage. Note that the notion of rigidity itself depends on the metrical framework.

**### Three Views**

This method of comparison of different pairs of views is reminiscent of taking a profile view to mensurate the orien- tation of the fiducial triangle and the depth of relief, a trivial affair. The essential structure-from-motion part of the so- lution has already been solved at the first stage. This is apparent from the perfect rank-order correlation of the ini- tial affinesolution.

**### CONCLUSIONS**

We have shown how the structure-from-motion problem may be solved in a stratified,highly structured manner.Here we discuss some of the implications.The first stage of the solution assumes

\* A small field of view

\* A smooth transformation in three-space

\* Affine constructions in the visual field.

and finds a three-dimensional model of the configuration modulo an arbitary affine transformation.

However, such considerations, important as they may be in practice, are of no importance for the basic principles involved.