Part IV

N-View Geometry

Untitled 1947, (Oil on sackcloth) by Asger Jorn (1914-1973)

Outline

This part is partly a recapitulation and partly new material.

Chapter 17 is the recapitulation. We return to two- and three-view geometry but now within a more general framework which naturally extends to four- and n-views. The fundamental projective relations over multiple views arise from the intersection of lines (back-projected from points) and planes (back-projected from lines). These intersection properties are represented by the vanishing of determinants formed from the camera matrices of the views. The fundamental matrix, the trifocal tensor, and a new tensor for four views – the *quadrifocal tensor* – arise naturally from these determinants as the multiple view tensors for two, three, and four views respectively. The tensors are what remains when the 3D structure and non-essential part of the camera matrices are eliminated. The tensors stop at four views.

These tensors are unique for each set of views, and generate relationships which are multi-linear in the coordinates of the image measurements. The tensors can be computed from sets of image correspondences, and subsequently a camera matrix for each view can be computed from the tensor. Finally, the 3D structure can be computed from the retrieved cameras and image correspondences.

Chapter 18 covers the computation of a reconstruction from multiple views. In particular the important factorization algorithm is given for reconstruction from affine views. It is important because the algorithm is optimal, but is also non-iterative.

Chapter 19 describes the auto-calibration of a camera. These are a set of methods for computing the internal parameters of a camera based on constraints over multiple images. In contrast to the traditional approach to calibration described in chapter 7, no explicit scene calibration object is used, but simply constraints such as that the internal parameters are common across the images, or that the camera rotates about its centre and does not change aspect ratio.

Chapter 20 emphasises the duality between points and cameras, and how this links various configurations and algorithms that have been given throughout this book. This chapter contains an algorithm for computing a reconstruction of six points imaged in 3-views.

Chapter 21 investigates the issue of whether points are in front of or behind one or more cameras. This is an issue that goes beyond the homogeneous representation used throughout the book which does not distinguish the direction of a ray.

Chapter 22 covers the important topic of those configurations for which the estimation algorithms described in this book will fail. An example is for resectioning, where the camera matrix cannot be computed if all the 3D points and the camera centre lie on a twisted cubic.