

Preface

Structure and motion recovery refers to the process of extracting three dimensional structure of the scene as well as camera motions by analyzing an image sequence. This is an important theme in computer vision, and great progress has been made both in theory and in practice during the last two decades. Successful applications include robot navigation, augmented reality, industrial inspection, medical image analysis, digital entertainment, and many more.

The book focuses on Euclidean structure and motion recovery, particularly on factorization based algorithms. The factorization method is based on bilinear formulation that decomposes image measurements directly into structure and motion components. Recent studies have extended the algorithm to recover structure of both nonrigid and dynamic objects, and experimental results have established its efficiency and potency. The book provides a comprehensive overview and an in-depth study of rigid and nonrigid factorization techniques. Our recently developed algorithm along with some latest results are presented in the book.

The book is suitable for graduate students, researchers, and industrial practitioners. Some background on projective geometry and matrix computation would greatly assist in understanding the fundamental ideas presented in the book. However, no profound knowledge of computer vision is required. The main contents of this book are as follows.

The first three chapters cover camera imaging geometry and their applications. Chapter 1 introduces some basic concepts and principles of imaging geometry, such as single and two-view geometry, image metrology, and three dimensional reconstruction. Chapter 2 reviews affine approximation model and presents a quasi-perspective projection model as a trade-off between simplicity and accuracy of affine and perspective projection models respectively. Chapter 3 investigates geometrical properties of quasi-perspective projection model, quasi-perspective projection matrix, fundamental matrix, plane induced homography, and quasi-perspective reconstruction.

Chapter 4 introduces basic principles of various affine and perspective factorization algorithms for structure and motion recovery of rigid, nonrigid, articulated, and multiple moving objects.

Chapters 5 and 6 deal with perspective extension of affine factorization algorithm. Chapter 5 describes two techniques to improve the performance of rigid perspective factor-

ization, one is a hybrid approach for projective depth estimation based on projective reconstruction, and the other is a Kruppa constraints based self-calibration scheme for a more universal camera model. Chapter 6 presents two algorithms for perspective factorization of nonrigid objects, the first one refines the depth scales using linear recursive estimation, and the second one is based on nonlinear optimization via minimization of perspective reprojection residuals.

Chapter 7 describes an alternative rotation constrained power factorization algorithm that efficiently integrates orthonormality and replicated block structure of the motion matrix into an iterative scheme.

Chapter 8 introduces a deformation weight constraint for nonrigid factorization and proves the invariability between structure and shape bases under Euclidean and affine transformations. Hence, the metric structure can be recovered using a stratification approach.

Chapter 9 applies the quasi-perspective projection model to structure and motion recovery and establishes a factorization framework for rigid and nonrigid objects under quasi-perspective assumption. Computational details are elaborated in the chapter and an extended Cholesky decomposition is proposed to recover the rotation part of the Euclidean upgrading matrix.

The appendix presents some mathematical facts that are widely used in the book, including projective geometry, matrix decomposition, least squares, and nonlinear estimation techniques.

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Waterloo, Canada
Windsor, Canada

Guanghui Wang
Jonathan Wu

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Wang, G.; Wu, J.

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