
Contents

Part I Introduction

1	Free-Viewpoint Video	5
1.1	Motivation	5
1.2	Components of a Free-Viewpoint Video System	6
1.3	Outline of the Thesis	8
2	Basic Concepts and Notation	11
2.1	Scene Geometry	11
2.2	Multi-View Geometry	11
2.3	The Visual Hull	14
2.4	Geometry Models	15
2.5	Color Consistency and Constancy	17
3	Related Work	19
3.1	Overview	19
3.2	Classification of 3D Reconstruction Techniques	19
3.3	Pre-calibrated Methods	20
3.4	Online-calibrated Methods	25
3.5	3D Video Systems	26

Part II Depth Reconstruction

4	Overview	33
4.1	Depth Reconstruction	33
4.2	Acquisition Hardware	34

5	Joint Depth and Background Estimation	37
5.1	Introduction	37
5.2	Reconstruction Algorithm	38
5.3	The Energy Functional	41
5.4	Energy Minimisation	44
5.5	Results	46
5.6	Conclusions	48
6	Temporally Coherent Depth	51
6.1	Introduction	51
6.2	Pre-processing	52
6.3	The Energy Functional	60
6.4	Results	62
6.5	Conclusions	64

Part III Surface Reconstruction

7	Overview	69
7.1	Introduction	69
7.2	Weighted Minimal Surfaces	70
7.3	Variational Methods in Computer Vision	71
7.4	Acquisition Hardware	75
8	Mathematical Foundations	79
8.1	Introduction	79
8.2	Some Background in Differential Geometry	79
8.3	Euler-Lagrange Equation	83
8.4	Corresponding Level Set Equation	85
8.5	Conclusions	86
9	Space-Time Isosurface Evolution	87
9.1	Introduction	87
9.2	Space-time 3D Reconstruction	87
9.3	Parallel Implementation	91
9.4	Results	94
9.5	Conclusions	97
10	Reconstructing the Geometry of Flowing Water	99
10.1	Introduction	99
10.2	General Reconstruction Problem	101
10.3	Implementation	103

10.4 Results	109
10.5 Conclusions	111

Part IV Video-based Rendering

11 Overview	117
11.1 Introduction	117
12 Dynamic Light Field Rendering	119
12.1 Introduction	119
12.2 Disparity Compensation	119
12.3 Interactive Rendering	121
12.4 Results	123
12.5 Conclusions	125
13 Free-Viewpoint Video Rendering	129
13.1 Introduction	129
13.2 Hardware Accelerated Rendering	130
13.3 Results	133
13.4 Conclusions	136
Discussion and Conclusions	137
14.1 Summary	137
14.2 Future Work	139
References	141