

Contents

Chapter 1	Introduction	1
1.1	Introduction to Computer Vision	2
1.1.1	Visual essentials	2
1.1.2	The goal of computer vision	3
1.1.3	Related disciplines	4
1.2	Computer vision Theory and Framework	7
1.2.1	Visual computational theory	7
1.2.2	Framework issues and improvements	13
1.2.3	A discussion on Marr's reconstruction theory	15
1.2.4	Research on new theoretical framework	18
1.2.5	Discussion from the Perspective of Psychological Cognition	21
1.3	Introduction to Image Engineering	24
1.3.1	Three levels of technology in image engineering	25
1.3.2	Research and application of image engineering	27
1.4	Introduction to Deep Learning	28
1.4.1	Deep learning overview	28
1.4.2	Deep learning core technology	34
1.4.3	Deep learning in computer vision	36
1.5	Organizations and content of this book	38
	References	40
Chapter 2	Camera Imaging and Calibration	41
2.1	Lightness Imaging Model	42
2.1.1	Photometric concepts	42
2.1.2	Basic Lightness Imaging Model	43
2.2	Space Imaging Model	44
2.2.1	Projection imaging geometry	44
2.2.2	Basic space imaging model	46
2.2.3	General space imaging model	50
2.2.4	Complete space imaging model	52
2.3	Camera Calibration Model	55
2.3.1	Linear camera model	55
2.3.2	Non-linear camera model	58
2.4	Camera Calibration Methods	62
2.4.1	Classification of calibration methods	62
2.4.2	Traditional calibration methods	64
2.4.3	Self-calibration methods	69
2.4.4	A calibration method for structured light active vision system	72
2.4.5	An on-line camera external parameter calibration method	79
	References	82
Chapter 3	Depth Image Acquisition	85
3.1	Depth Image and Depth Imaging	86
3.1.1	Depth images	86

3.1.2	Depth imaging	88
3.2	Direct Depth Imaging	89
3.2.1	Introduction to laser scanning	89
3.2.2	Time of flight	94
3.2.3	LiDAR	97
3.2.4	Structured light	98
3.2.5	Moiré contour striping	101
3.3	Indirect Depth Imaging	105
3.3.1	Binocular horizontal mode	106
3.3.2	Binocular convergent horizontal mode	112
3.3.3	Binocular axial mode	115
3.4	Single-Pixel Depth Imaging	117
3.4.1	The principle of single-pixel imaging	117
3.4.2	Single-pixel camera	119
3.4.3	Single-pixel 3D imaging	121
3.5	Biocular Vision and Stereopsis Vision	123
3.5.1	Biocular vision and binocular vision	123
3.5.2	From monocular to binocular stereo	124
	References	125
Chapter 4	3D Point Cloud Data Acquisition and Processing	127
4.1	Point Cloud Data Overview	128
4.1.1	Point cloud data acquisition modes	128
4.1.2	Point cloud data types	129
4.1.3	Point cloud data processing tasks	129
4.1.4	LiDAR test dataset	131
4.2	Point Cloud Data Preprocessing	132
4.2.1	Point cloud data trapping	132
4.2.2	Point cloud data denoising	133
4.2.3	Point cloud data ground area filtering	135
4.2.4	Point cloud data reduction/compression	135
4.2.5	Multi-platform point cloud data registration	138
4.2.6	Registration of Point cloud data and image data	142
4.3	Laser Point Cloud 3D Modeling	143
4.3.1	Delaunay triangulation	143
4.3.2	Patch fitting	144
4.4	Texture Mapping for 3D Models	148
4.4.1	Color texture mapping	149
4.4.2	Geometric texture mapping	150
4.4.3	Procedural texture mapping	151
4.5	Point Cloud Feature Description	152
4.5.1	Global and local feature descriptors	152
4.5.2	Signature of histogram of orientation	153
4.5.3	Rotation projection statistics	153
4.5.4	Tri-orthogonal local depth map	154
4.6	Point Cloud Understanding and Deep Learning	155

4.7	Bionic Optimized Registration of Point Clouds	156
4.7.1	Cuckoo search	157
4.7.2	Improved cuckoo search	158
4.7.3	Point cloud registration application	159
	References	161
Chapter 5	Binocular Stereo Vision	165
5.1	Region-Based Binocular Stereo Matching	166
5.1.1	Template matching	166
5.1.2	Stereo matching	170
5.2	Feature-Based Binocular Stereo Matching	177
5.2.1	The basic steps	177
5.2.2	Scale invariant feature transformation	181
5.2.3	Speed up robustness features	184
5.2.4	Dynamic programming matching	191
5.3	Parallax Map Error Detection and Correction	192
5.3.1	Error detection	193
5.3.2	Error correction	194
5.4	Stereo Matching Based on Deep Learning	197
5.4.1	Stereo matching networks	197
5.4.2	Matching based on feature cascade CNN	199
	References	200
Chapter 6	Multi-Ocular Stereo Vision	203
6.1	Horizontal Multi-Ocular Stereo Matching	204
6.1.1	Multi-ocular images and SSD	204
6.1.2	Inverse distance and SSSD	206
6.2	Orthogonal Trinocular Stereo Matching	209
6.2.1	Orthogonal trinocular	209
6.2.2	Orthogonal matching based on gradient classification	214
6.3	Multi-Ocular Stereo Matching	219
6.3.1	Matching of arbitrarily arranged trinocular stereo	220
6.3.2	Orthogonal multi-ocular stereo matching	225
6.4	Equal Baseline Multiple Camera Set	227
6.4.1	Image acquisition	227
6.4.2	Image merging methods	228
6.5	Single Camera Multi-Mirror Catadioptric System	231
6.5.1	Overall system structure	231
6.5.2	Imaging and calibration models	232
	References	234
Chapter 7	Monocular Multi-Image Scene Restoration	237
7.1	Monocular Image Scene Restoration	238
7.2	Shape from Illumination	240
7.2.1	Scene brightness and image brightness	240
7.2.2	Surface reflection characteristics and brightness	244

	7.2.3	Scene surface orientation	247
	7.2.4	Reflectance map and image brightness constraint equation	249
	7.2.5	Solving the image brightness constraint equation	253
7.3		Shape from Motion	256
	7.3.1	Optical flow and motion fields	257
	7.3.2	Optical flow field and optical flow equation	260
	7.3.3	Solving the optical flow equation	262
	7.3.4	Optical flow and surface orientation	269
	7.3.5	Optical flow and relative depth	273
7.4		Shape from Segmented Contour	274
7.5		Photometric Stereo Review	276
	7.5.1	Light source calibration	276
	7.5.2	Non-Lambertian surface reflection models	277
	7.5.3	Color photometric stereo	278
	7.5.4	3D reconstruction methods	279
7.6		GAN-Based Photometric Stereo	279
	7.6.1	Network structure	281
	7.6.2	Loss function	282
		References	283
Chapter 8		Monocular Single-Image Scene Restoration	287
	8.1	Shape from Shading	288
		8.1.1 Shades and shapes	288
		8.1.2 Solving the image brightness constraint equation	292
	8.2	Shape from Texture	300
		8.2.1 Monocular imaging and texture distortion	300
		8.2.2 Restore surface orientation from texture changes	303
		8.2.3 Texture vanishing point detection	311
	8.3	Shape from Focus.....	316
	8.4	Estimating Pose from Perspective Three-Point.....	318
		8.4.1 Perspective three-point problem	319
		8.4.2 Iterative solution	320
	8.5	Shape from Shading in Hybrid Surface Perspective Projection	321
		8.5.1 Improved Ward reflection model	322
		8.5.2 Image brightness constraint equation under perspective projection	323
		8.5.3 Solving the image brightness constraint equation	325
		8.5.4 Equations based on the Blinn-Phong reflection model	327
		8.5.5 Solving the new image brightness constraint equation	328
		References	330
Chapter 9		Generalized Matching	333
	9.1	Introduction to Matching	334
		9.1.1 Matching strategy	335
		9.1.2 Matching classification	336
		9.1.3 Matching evaluation	337
	9.2	Object Matching	338

9.2.1	Matching metrics	338
9.2.2	Corresponding point matching	341
9.2.3	Inertia equivalent ellipse matching	343
9.3	Dynamic Pattern Matching	345
9.3.1	Matching process	345
9.3.2	Absolute pattern and relative pattern	346
9.4	Matching and Registration	349
9.4.1	Implementation of registration	349
9.4.2	Heterogeneous remote sensing image registration based on feature matching ..	351
9.4.3	Image matching based on spatial relationship reasoning	352
9.5	Relationship Matching	353
9.6	Graph Isomorphism Matching	358
9.6.1	Introduction to graph theory	358
9.6.2	Graph isomorphism and matching	361
9.7	Labelling and Matching of Line Drawing	364
9.7.1	Contour labelling	365
9.7.2	Structure reasoning	366
9.7.3	Backtracking labelling	367
9.8	Multimodal Image Matching	369
9.8.1	Region-based technology	370
9.8.2	Feature-based technology	372
	References	374
Chapter 10	Simultaneous Location and Mapping	377
10.1	SLAM Overview	378
10.1.1	Laser SLAM	378
10.1.2	Visual SLAM	381
10.1.3	Comparison and combination	383
10.2	Laser SLAM Algorithms	385
10.2.1	Gmapping algorithm	385
10.2.2	Cartographer algorithm	388
10.2.3	LOAM algorithm	392
10.3	Visual SLAM Algorithms	394
10.3.1	ORB-SLAM algorithm series	395
10.3.2	LSD-SLAM algorithm	400
10.3.3	SVO algorithm	408
10.4	Swarm Robots and Swarm SLAM	410
10.4.1	Characteristics of swarm robots	411
10.4.2	Problems to be solved by swarm SLAM	412
10.5	Some New Trends of SLAM	413
10.5.1	Combination of SLAM and Deep Learning	413
10.5.2	Combination of SLAM and multi-agent	414
	References	416
Chapter 11	Spatial-Temporal Behavior Understanding	419
11.1	Spatial-Temporal Technology	420

11.1.1	New research domains	420
11.1.2	Multiple levels	421
11.2	Action Classification and Recognition	422
11.2.1	Action classification	423
11.2.2	Action recognition	425
11.3	Actor and Action Joint Modeling	428
11.3.1	Single-label actor-action recognition	429
11.3.2	Multiple-label actor-action recognition	430
11.3.3	Actor-action semantic segmentation	432
11.4	Activity and Behavior Modeling	435
11.4.1	Action modeling	436
11.4.2	Activity modeling and recognition	442
11.4.3	Joint point-based behavior recognition	447
11.5	Abnormal Event Detection	450
11.5.1	Automatic activity analysis	450
11.5.2	Classification of abnormal event detection methods	455
11.5.3	Detection based on convolutional autoencoder block learning	457
11.5.4	Detection based on one-class neural network	459
	References	460
	Index	463