

# Contents

- 1 Introduction . . . . . 1**
  - 1.1 Goals . . . . . 3
  - 1.2 Challenges and Main Contributions . . . . . 5
  - 1.3 Publications . . . . . 7
  - 1.4 The Proposed Framework . . . . . 11
  - 1.5 Book Outline . . . . . 13
  - References . . . . . 14
- 2 Preliminaries of 3D Point Cloud Processing . . . . . 17**
  - 2.1 From the Real World to a Scene and Its Representation . . . . . 17
  - 2.2 On Points and Clouds, and Point Clouds . . . . . 19
  - 2.3 Point Cloud Acquisition . . . . . 20
    - 2.3.1 Passive Techniques . . . . . 21
    - 2.3.2 Active Techniques . . . . . 22
  - 2.4 Generation of 2D Image Representations for 3D Point Clouds. . . . . 24
  - 2.5 Point Quality Assessment . . . . . 25
    - 2.5.1 Influencing Factors and Related Work . . . . . 26
    - 2.5.2 Filtering Based on Intensity Information. . . . . 27
    - 2.5.3 Filtering Based on Range Reliability . . . . . 28
    - 2.5.4 Filtering Based on Local Planarity . . . . . 29
    - 2.5.5 A Qualitative Comparison of Different Measures . . . . . 31
    - 2.5.6 A Quantitative Comparison of Different Measures . . . . . 33
  - 2.6 Conclusions . . . . . 35
  - References . . . . . 36
- 3 A Brief Survey on 2D and 3D Feature Extraction . . . . . 39**
  - 3.1 What Is a Feature?. . . . . 39
  - 3.2 2D Feature Extraction . . . . . 40
    - 3.2.1 Overall Appearance . . . . . 41
    - 3.2.2 Pixel Attributes . . . . . 42

3.2.3	Texture . . . . .	42
3.2.4	Shape . . . . .	43
3.2.5	Local Features . . . . .	44
3.3	3D Feature Extraction . . . . .	45
3.3.1	Point Attributes . . . . .	45
3.3.2	Shape . . . . .	46
3.3.3	Local Features . . . . .	47
3.4	Discussion . . . . .	48
3.5	Conclusions . . . . .	50
	References . . . . .	51
<b>4</b>	<b>Point Cloud Registration . . . . .</b>	<b>55</b>
4.1	Motivation and Contributions . . . . .	56
4.2	Related Work . . . . .	59
4.2.1	Feature Extraction . . . . .	59
4.2.2	Keypoint-Based Point Cloud Registration . . . . .	63
4.3	A Novel Framework for Keypoint-Based Point Cloud Registration. . . . .	64
4.3.1	2D Image Representations . . . . .	64
4.3.2	Point Quality Assessment . . . . .	66
4.3.3	Feature Extraction and Matching . . . . .	66
4.3.4	Forward Projection of 2D Keypoints to 3D Space . . . . .	72
4.3.5	Correspondence Weighting . . . . .	73
4.3.6	Point Cloud Registration . . . . .	77
4.4	Experimental Results . . . . .	85
4.4.1	Dataset. . . . .	85
4.4.2	Experiments . . . . .	86
4.4.3	Results. . . . .	87
4.5	Discussion . . . . .	98
4.6	Conclusions . . . . .	104
	References . . . . .	105
<b>5</b>	<b>Co-Registration of 2D Imagery and 3D Point Cloud Data . . . . .</b>	<b>111</b>
5.1	Motivation and Contributions . . . . .	112
5.2	Related Work . . . . .	114
5.2.1	Indirect Co-Registration of 3D Point Clouds and Thermal Infrared Images . . . . .	115
5.2.2	Direct Co-Registration of 3D Point Clouds and Thermal Infrared Images . . . . .	116
5.2.3	Direct Generation of 3D Point Clouds from Thermal Infrared Images. . . . .	116

5.3	A Novel Framework for Keypoint-Based 3D Mapping of Thermal Information . . . . .	117
5.3.1	Radiometric Correction . . . . .	117
5.3.2	Geometric Calibration . . . . .	118
5.3.3	Feature Extraction and Matching . . . . .	121
5.3.4	Keypoint-Based Co-Registration of 3D and 2D Information. . . . .	123
5.4	Experimental Results . . . . .	128
5.4.1	Data Acquisition . . . . .	128
5.4.2	Experiments . . . . .	130
5.4.3	Results. . . . .	130
5.5	Discussion . . . . .	131
5.6	Conclusions . . . . .	137
	References . . . . .	138
<b>6</b>	<b>3D Scene Analysis . . . . .</b>	<b>141</b>
6.1	Motivation and Contributions . . . . .	142
6.2	Related Work . . . . .	145
6.2.1	Neighborhood Selection: Single-Scale Representation Versus Multi-Scale Representation. . . . .	145
6.2.2	Feature Extraction: Sampled Features Versus Interpretable Features. . . . .	148
6.2.3	Feature Selection: All Features Versus Relevant Features . . . . .	149
6.2.4	Classification: Individual Feature Vectors Versus Contextual Information. . . . .	151
6.3	A Novel Framework for 3D Scene Analysis . . . . .	153
6.3.1	Neighborhood Selection . . . . .	154
6.3.2	Feature Extraction . . . . .	159
6.3.3	Feature Selection. . . . .	165
6.3.4	Classification . . . . .	170
6.4	Extension Toward Large-Scale 3D Scene Analysis. . . . .	175
6.5	Extension by Involving Contextual Information. . . . .	177
6.5.1	Association Potentials . . . . .	179
6.5.2	Interaction Potentials . . . . .	179
6.5.3	Definition of the Neighborhood. . . . .	180
6.5.4	Training and Inference . . . . .	181
6.6	Experimental Results . . . . .	182
6.6.1	Datasets . . . . .	182
6.6.2	Experiments . . . . .	185
6.6.3	Results. . . . .	188
6.7	Discussion . . . . .	209
6.7.1	Our Main Framework . . . . .	209
6.7.2	Extension Toward Data-Intensive Processing . . . . .	213
6.7.3	Extension by Involving Contextual Information. . . . .	215

6.8 Conclusions . . . . . 216

References . . . . . 217

**7 Conclusions and Future Work . . . . . 225**

**Index . . . . . 231**

Reconstruction and Analysis of 3D Scenes  
From Irregularly Distributed 3D Points to Object Classes  
Weinmann, M.  
2016, XXII, 233 p. 81 illus., 69 illus. in color., Hardcover  
ISBN: 978-3-319-29244-1