
Contents

Kurzfassung	v
Abstract	vii
Acknowledgements	ix
Contents	xiii
List of Figures	xvii
Nomenclature	xxi
1 Introduction	25
1.1 Motivation	25
1.2 Outline	27
2 State of the Art	29
2.1 3D Capture Technologies	31
2.1.1 Holographic Imaging	32
2.1.2 Passive Stereo	33
2.1.3 Deep Convolutional Neural Networks	34
2.1.4 Time of Flight	35
2.1.5 Laser-Based Scanning	36
2.1.6 Structured Light	36
2.2 3D Rendering Technologies	38
2.2.1 Image-Based Rendering	38
2.2.2 Geometry-Based Rendering	39
2.2.3 Holographic Fringe Rendering	39
2.3 3D Display Technologies	41
2.3.1 Stereoscopic Displays	41
2.3.2 Volumetric Displays	42
2.3.3 Holographic Displays	43

3	Calibration	47
3.1	Related Work	48
3.2	The Working Principle	49
3.3	Geometric Calibration	50
3.3.1	Estimation of the Linear Intrinsic and Extrinsic Coefficients . . .	51
3.3.2	Estimation of Non-Linear Distortion Coefficients	53
3.3.3	Gray Code Calibration Sequence	56
3.3.4	Modified Calibration Sequence	58
3.4	Decomposition of the Scaled Measurement Matrix	60
3.5	Results of the Multi-Camera Multi-Projector Calibration	63
3.5.1	Pixel Reprojection Error	65
3.5.2	Online Integration of the Automated Calibration Procedure . . .	66
3.6	Photometric Calibration	68
4	Synchronization	73
4.1	The Structured Light Projection System	74
4.2	Synchronization with an External Microcontroller	75
4.3	Proposed Time Multiplex Schemes	76
5	3D Reconstruction	81
5.1	Phase Shifted Structured Light	81
5.2	Phase Unwrapping	84
5.3	Epipolar Constrained Triangulation	86
5.3.1	Ray-Ray Triangulation	87
5.3.2	Ray-Plane Triangulation	89
5.3.3	2D Triangulation	90
5.4	Image Guided Phase Unwrapping	93
5.5	Point Cloud to Mesh Conversion	98
5.6	Hole Filling	100
6	Consensus-Based Texturing	105
6.1	Shadow Mapping	106
6.2	Consensus-Based Texturing	107
6.3	Depth Estimation and Depth-Map Completion	109
6.4	Timing Overview	111
7	Full Parallax Free Viewpoint Video	115
7.1	Fixed-Parallax Limitations in Stereoscopic 3D	117
7.1.1	Vergence Vs. Accommodation	118
7.1.2	Stereopsis Vs. Blur	118
7.1.3	The Native Pixel Parallax	119
7.1.4	Screen Size and Viewing Distance	120
7.2	Adaptive Parallax	121
7.3	SLAM Background Modeling	124
7.3.1	Image Registration	125

7.3.2	Camera Pose Estimation	126
7.3.3	Patch-Based Refinement of the Textured Mesh	128
7.4	Headtracking	128
7.5	Fusion with the Online Acquisition	131
8	Performance Evaluation	135
8.1	Qualitative Comparison	136
8.2	Quantitative Comparison	138
8.2.1	Hybrid Phase Shifting	139
8.2.2	ELAS	141
8.2.3	Kinect	142
8.2.4	Comparison of the Error Distribution	143
8.3	Evaluation on Physical Reference Objects	145
8.3.1	The Semi Cube	145
8.3.2	The Circular Saw Blade	148
8.3.3	The Agilent	150
9	Outlook and Conclusion	155
9.1	Image Deconvolution and the Effect of the Point Spread Function in Textured Regions	156
9.2	Implications on Holographic Television	160
	Bibliography	163
	Appendices	181
A	Triangulation by Means of Singular Value Decomposition	181
B	Reference Dataset Selection	185
B.1	Justification of the Real-Time Kinect Results	188
C	GLSL Code Examples	191