

Contents

Acknowledgement	vii
Abstract	xi
Kurzfassung	xv
Nomenclature	xxi
List of Figures	xxix
List of Tables	xxxiii
1. Introduction	1
1.1. Motivations and Contributions	4
1.2. Outline	8
2. Phase-Shift-Based Time-of-Flight Imaging Systems	11
2.1. Introduction to Depth Imaging	12
2.2. Phase-Shift-Based Time-of-Flight Imaging Systems	23
2.3. The Photonic Mixer Device (PMD)	49
2.4. Current Limits of the PMD-Based Time-of-Flight Imaging . .	72
3. Fundamentals of Compressive Sensing	89
3.1. Introduction to Compressive Sensing	89
3.2. Sensing Matrices	116
3.3. Sparsity Bases	142
3.4. Recovery Methods	171
4. Compressive Sensing for the Photonic Mixer Device	207
4.1. Introduction and Application Domains	207
4.2. Solving Preliminary Issues	214
4.3. An Accurate Sensing Model: HR Characterization of PMD Pixels	252

4.4. Sparse Recovery in Spatial Domain	285
4.5. Sparse Recovery in Time-Frequency Domain	318
5. CS-PMD: A Compressive Sensing ToF Camera based on the PMD353	
5.1. General System Description	353
5.2. Hardware	362
5.3. Software: 3D Sparse Recovery from Few Measurements . . .	371
6. Conclusions	387
6.1. Summary	387
6.2. Future Work	390
A. Appendix	395
A.1. Cross-Correlation Between Sinusoidal Signals	395
A.2. Cross-Correlation Between Periodic Signals	396
A.3. Phase Shift, Amplitude and Offset Estimation	399
A.4. Depth Measurement Uncertainty	401
A.5. Optical Power Received by a Pixel	402
A.6. Experimental Evaluation of the Delay in the Illumination . .	405
A.7. Mutual and Matrix Coherences	414
A.8. Adaptive High Dynamic Range: Complementary Material . .	416
A.9. Inverse Freeman-Tukey Transformation for Poisson Data . . .	423
A.10. Fluorescence Lifetime Microscopy and ToF Imaging	425
A.11. The CS-PMD Camera Prototype	428
A.12. Depth Measurement Uncertainty in the CS-PMD System . .	435
References	437
Publications	495
First author	495
Coauthor	496