

Contents

List of Figures	XI
List of Tables	XIII
Notation	XVI
1 Introduction	1
1.1 Indoor Localization Systems	2
1.1.1 Wireless Based Indoor localization	3
1.1.2 IMU Based Infrastructure-free Indoor Localization	6
1.1.3 Simultaneous Localization and Mapping (SLAM)	7
1.1.4 Visible Light or Ultrasound Based Indoor Localization	8
1.2 Comparison of Localization Systems	8
1.3 General Information on UWB	9
1.4 NLOS Identification for UWB	12
1.5 Outline and Contributions	14
1.5.1 Contributions	16
1.5.2 Outline	16
1.6 Publications	18
2 Analysis of UWB Based Localization System	21
2.1 Factors Influencing Localization Accuracy	22
2.2 UWB LOS and NLOS Measurement Error	29
2.3 UWB Signal Propagation Description	35
2.3.1 Theoretical Explanation for the Relationship between CIRs and Accurate/Inaccurate Measurements	36
2.3.2 Support Vector Machine	41
2.3.3 CIR and Accurate/Inaccurate Measurements in Real Office Environments	44
3 UWB Localization Filter Algorithms	47
3.1 Kalman Filter	50
3.1.1 Kalman Filter Principle	51
3.1.2 Kalman Filter for Localization	53
3.2 Extended Kalman Filter	55
3.3 Iterated Extended Kalman Filter	57

3.4	Particle Filter	57
3.4.1	Particle Filter Principle	60
3.4.2	Particle Filter for Localization	63
3.5	Comparison of Filters	65
4	Hard NLOS Identification and Mitigation Approaches	67
4.1	NLOS Identification	67
4.2	NLOS Mitigation	71
5	UWB Localization in Office Environment	73
5.1	Localization with Three BSs	74
5.2	Localization with Redundant BSs	77
5.2.1	Extracted Features from CIRs	78
5.2.2	Effective Signal Length of CIRs	82
5.2.3	Test Results	84
5.3	Summary	87
6	UWB Localization in Harsh Industrial Environment	89
6.1	Overview of the TOA/TDOA Combination Approach	92
6.2	Accurate Range Difference Detection	93
6.3	Test Results	97
6.4	Summary	102
7	UWB NLOS Detection and Mitigation Based on IMU	105
7.1	TOA Based UWB/IMU Fusion System	111
7.2	TDOA Based UWB/IMU Fusion System	120
7.3	Summary	126
8	Conclusions	127
	Bibliography	136