



Sromona Chatterjee (Autor)
**Computer Vision and Machine Learning in
Sustainable Mobility: The Case of Road Surface
Defects**



Göttinger Wirtschaftsinformatik

Herausgeber: J. Biethahn¹ • L. M. Kolbe • M. Schumann

Sromona Chatterjee

**Computer Vision and Machine Learning in
Sustainable Mobility**

The Case of Road Surface Defects

Band 104



Cuvillier Verlag Göttingen

Internationaler wissenschaftlicher Fachverlag

<https://cuvillier.de/de/shop/publications/8280>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentzsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen,
Germany

Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>



Contents

Acronyms	xii
List of Figures	xiv
List of Tables	xvii
1 Introduction	1
1.1 Motivation	1
1.2 Research Questions	5
1.2.1 Road Area Segmentation and Data Preparation	6
1.2.2 Classifier Based Defect Detection on Road Surfaces at the Superpixel Level	9
1.2.3 Keypoint Matching Based Defect Detection on Road Surfaces at the Pixel Level	10
1.2.4 A Vision-based Decision Support System for Road Surface Defect Detection	11
1.3 Structure of the Dissertation	12
1.3.1 Publications Included in the Dissertation	12
1.3.2 Connection between Chapters, Research Questions and Developed Approaches	12
1.4 Positioning of the Work in Information Systems Research	17
1.5 Anticipated Contributions	18
2 Understanding the Scene Data- Pavement Area Grouping in Images	21
2.1 Introduction	22
2.2 Related Work	24
2.3 Data Collection and Preparation	27



2.4	Feature Extraction	27
2.4.1	Color, Texture, and Histogram of Oriented Gradients Features	28
2.5	Region Based Merging	30
2.5.1	Initial Region Growing	31
2.5.2	Iterative Merging Procedure	32
2.6	Implementation Environment	36
2.7	Results	36
2.7.1	Pavement Region Merging	37
2.7.2	Pavement Region Detection and Extraction	38
2.7.3	Evaluations	40
2.8	Discussion	43
2.8.1	Limitations and Future Work	47
2.9	Conclusion	48
3	Intelligent Road Maintenance- A Machine Learning Approach for Surface Defect De- tection	49
3.1	Introduction	50
3.2	Related Work	52
3.3	Data Collection and Preparation	55
3.3.1	Generating Road Images from Scene Images	55
3.3.2	Pre-processing of Road Images and Superpixel Generation	56
3.3.3	Final Road Image Dataset for Defect Detection	57
3.4	Problem Formulation	58
3.5	Feature Extraction	58
3.5.1	Variance-of-Gabor (VoG) features	60
3.6	Evaluations	62
3.7	Discussion and Future Work	63



3.8	Conclusion	69
4	Defect Detection on Road Surfaces Using Fuzzy Image Descriptors and Keypoint Matching	71
4.1	Introduction	72
4.2	The Framework	74
4.3	Related Work	76
4.4	Data Preparation	79
4.5	Background of the Concepts	79
4.5.1	Fuzzy Logic and Membership Functions	79
4.5.2	Gamma Mixture Fuzzy Model	80
4.5.3	Image Feature Descriptors and Keypoint Matching	82
4.6	Methodology	83
4.6.1	Transforming the Intensity Image into Gradient Image	83
4.6.2	Gamma Mixture Fuzzy Model Based Keypoint Generation	83
4.6.3	Obtaining Fuzzy Feature Descriptors at Keypoints	85
4.6.4	Keypoint Matching Between Images for Crack and Defect Detection	88
4.7	Results and Evaluations	90
4.8	Discussion	91
4.9	Conclusion	95
5	Smart Infrastructure Monitoring- Development of a Decision Support System for Vision-Based Road Crack Detection	97
5.1	Introduction	98
5.2	Research Background	100
5.2.1	Vision-based Techniques for Road Surface Crack Detection	100
5.2.2	Information Systems for Road Infrastructure Management	101
5.3	Research Approach	103



5.3.1	Iteration 1: Designing Framework for the DSS	104
5.3.2	Iteration 2: Develop and Implement the DSS	104
5.3.3	Iteration 3: Evaluation and Publication	105
5.4	Results	107
5.4.1	Requirements	107
5.4.2	Vision-based Crack Detection Decision Support System	108
5.5	Evaluation	112
5.5.1	Performance	112
5.5.2	Decision Support	115
5.6	Design Theory	115
5.7	Discussion	116
5.8	Conclusion	119
6	Contribution and Conclusion	121
6.1	Findings and Results	121
6.1.1	Road Area Segmentation	121
6.1.2	Classifier Based Defect Detection on Road Surfaces at the Superpixel Level	123
6.1.3	Keypoint Matching Based Defect Detection on Road Surfaces at the Pixel Level	124
6.1.4	A Vision-based Decision Support System for Road Surface Defect Detection	127
6.1.5	Comparison Between Different Approaches for Crack Detection	130
6.2	Implications for Theory and Practice	137
6.2.1	Implications for Theory	137
6.2.2	Implications for Practice	141
6.3	Limitations and Future Research	145
6.4	Conclusion	146



<i>CONTENTS</i>	xi
References	149
Appendix	163