
Multiple-Sensor Based Approach for Road Terrain Classification

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Certificate of Original Authorship

I, Shifeng Wang, certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree except as fully acknowledged within the text.

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Contents

List of Abbreviations	IX
List of Figures	X
List of Tables.....	XIII
Abstract	XV
Chapter I.....	1
Introduction	1
1.1 Background	1
1.2 Motivation.....	2
1.3 Contributions.....	5
1.4 Publications.....	5
1.5 Thesis Overview	6
Chapter II.....	8
Review of Related Work.....	8
2.1 Accelerometer Applications.....	8
2.1.1 Small Sized Rover Platform Using Accelerometer	9
2.1.2 Road Vehicle Using Accelerometer.....	12
2.2 Camera Applications	13
2.2.1 Small Sized Rover Using Camera	13

2.2.2 Road Vehicle Using Camera	15
2.3 LRF Applications	16
2.3.1 Small Sized Rover Using LRF.....	16
2.3.2 Road Vehicle Using LRF	18
2.4 Mutiple-Sensor Applications.....	20
2.4.1 Small Sized Rover Using Multiple Sensors	20
2.4.2 Road Vehicle Using Multiple Sensors.....	23
2.5 Conclusion	24
Chapter III.....	25
Acceleration Based Road Terrain Classification.....	25
3.1 Road Profile Estimation.....	26
3.1.1 Acceleration (acc-t)	26
3.1.2 Quarter Vehicle Model (acc-t to y-t).....	27
3.1.3 Vertical Displacement (y-t)	29
3.1.4 Speed (v-t)	31
3.1.5 Speed to Displacement (v-t to x-t).....	32
3.1.6 Road Profile (y-x).....	32
3.2 Features Extraction	36
3.2.1 FFT feature extracted from road profile (y-x).....	37

3.2.2 FFT feature extracted from acceleration (<i>acc-t</i>).....	42
3.2.3 Fast wavelet transform feature extracted from acceleration (<i>acc-t</i>) and road profile (<i>y-x</i>).....	43
3.3 Normalization.....	44
3.4 Principal Component Analysis.....	45
3.5 K-Fold Cross Validation	45
3.6 Alternative Classifiers.....	46
3.6.1 Naïve Bayes Classifier.....	47
3.6.2 Neural Network Classifier	48
3.6.3 Support Vector Machines Classifier	50
3.7 Experiment	52
3.7.1 Experiment Platform	52
3.7.2 Acceleration Based Experiments	55
3.8 Experiment Results	58
3.8.1 Feature Selection	58
3.8.2 Speed Dependency	60
3.8.3 Classifiers Selection.....	64
3.8.4 Acceleration Based Experiment Result	66
3.9 Conclusion.....	73

Chapter IV.....	74
Image Based Road Terrain Classification	74
4.1 Texture Features from Image.....	75
4.2 Image Feature Matrix Establishment.....	76
4.2.1 Gray-Level Co-occurrence Matrix	76
4.2.2 Feature Extraction and Feature Matrix Formation.....	79
4.3 Experiment	83
4.3.1 Experimental Platform	83
4.3.2 Image Based Experiments	84
4.4 Experiment Results	84
4.5 Conclusion	94
Chapter V.....	95
LRF Based Road Terrain Classification	95
5.1 Geometric Arrangement of the LRF.....	95
5.2 Reconstruction of the Road Surface	96
5.2.1 Range Data Processing.....	97
5.2.2 Speed Data Processing.....	98
5.2.3 Road Surface	99
5.3 Feature Matrix.....	100

5.4 Experiment	101
5.4.1 Experimental Platform	101
5.4.2 LRF Based Experiments	102
5.5 Experiment Results	102
5.5.1 Speed Independency.....	103
5.5.2 LRF Based Experiment.....	104
5.6 Conclusion	109
Chapter VI Multiple-Sensor Based Road Terrain Classification	110
6.1 Predicting LRF Based Probe.....	111
6.2 Markov Random Field	113
6.2.1 Conditional Independence Properties	114
6.2.2 Factorization Properties.....	116
6.3 Establishment of MRF Application.....	119
6.3.1 Nodes in MRF	119
6.3.2 Variable Values of Nodes in MRF	120
6.3.3 Clique Potentials in MRF	121
6.3.4 Values of Clique Potentials in MRF	122
6.3.5 Energy Function	122
6.3.6 Optimization.....	124

6.4 Experiment	124
6.4.1 Experimental Platform	124
6.4.2 Multiple-Sensor Fusion Based Experiment	125
6.5 Experiment Results	125
6.6 Conclusion	131
Chapter VII.....	133
Conclusion and Future Direction	133
7.1 Conclusion	133
7.2 Future Direction	135
References.....	136

LIST OF ABBREVIATIONS

CRUISE	CAS Research Ute for Intelligence, Safety and Exploration
c/m	cycles/meter
DARPA	Defense Advanced Research Projects Agency
DMU	Differential Measurement Unit
FFT	Fast Fourier Transform
FPS	Frame per Second
FWT	Fast Wavelet Transform
GLCM	Grey-Level Co-occurrence Matrix
GPS	Global Positioning System
IMU	Inertial Measurement Unit
LRF	Laser Range Finder
MSE	Mean Squared Errors
MV	Majority Vote
PCA	Principal Component Analysis
PSD	Power Spectral Density
RPM	Revolutions per Minute
SVM	Support Vector Machine
USB	Universal Serial Bus

LIST OF FIGURES

Figure 1.1 A vehicle on mud terrain.....	3
Figure 1.2 A vehicle on rocky terrain.....	4
Figure 1.3 A vehicle on snow terrain.....	4
Figure 3.1 Illustration of road profile estimation.....	26
Figure 3.2 the quarter car model of the experimental vehicle.....	27
Figure 3.3 Even sampling and even profile with constant speed.....	30
Figure 3.4 Even sampling and uneven profile with varying speed.....	30
Figure 3.5 Profiles of four road terrain types.....	33
Figure 3.6 Histograms of four road terrain types.....	35
Figure 3.7 Illustration of features extraction.....	36
Figure 3.8 Procedure of forming the FFT feature matrix.....	37
Figure 3.9 Road profile ($y-x$) – special frequency feature extraction.....	37
Figure 3.10 Spatial frequency distributions of four road types.....	39
Figure 3.11 Spatial frequency domain of four road types.....	40
Figure 3.12 Acceleration ($acc-t$) – time frequency feature extraction.....	42
Figure 3.13 Acceleration/road profile data – FWT feature extraction.....	43
Figure 3.14 Linear SVM.....	50

Figure 3.15 Research platform: CRUISE.....	52
Figure 3.16 The hardware structure of the system.....	53
Figure 3.17 The mounted accelerometer on the suspension of CRUISE.....	54
Figure 3.18 Data Collection Routines of Four Road Types.....	55
Figure 3.19 Acceleration based experiment label sequence.....	67
Figure 4.1 Four types of road terrain surfaces.....	74
Figure 4.2 Angular relationships with nearest neighbour.....	76
Figure 4.3 The mounted camera on top of the frame.....	82
Figure 4.4 Image based experiment label sequence.....	85
Figure 4.5 (a) Image sequence of an asphalt terrain segment.....	88
Figure 4.5 (b) Image sequence of a grave terrain segment.....	89
Figure 4.6 Poor quality images.....	92
Figure 5.1 The geometric arrangement of the LRF.....	95
Figure 5.2 Reconstruction of the road surface.....	96
Figure 5.3 Mounting geometry of the LRF.....	96
Figure 5.4 Three-dimensional surface data of four different road types.....	98
Figure 5.5 The mounted downward-looking LRF.....	100
Figure 5.6 LRF based experiment label sequence.....	104
Figure 6.1 The mounted forward-looking LRFs.....	110

Figure 6.2 An example of an undirected graph.....	113
Figure 6.3 A Markov blanket of a node in an undirected graph.....	115
Figure 6.4 A four-node undirected graph.....	116
Figure 6.5 MRF model for road terrain identification.....	118
Figure 6.6 MRF experiment label sequence.....	126

LIST OF TABLES

Table 3.1 Parameters for the quarter car model.....	28
Table 3.2 Parameters of height of four road terrain types.....	34
Table 3.3 Locations of the data collection experiments.....	56
Table 3.4 Classification with different feature selection.....	58
Table 3.5 Classification of same road type with different speeds as different classes.....	60
Table 3.6 FFT feature on acceleration and road profile based classification accuracy training and testing with different speeds.....	61
Table 3.7 FFT feature on acceleration and road profile based classification results training and testing with different speeds.....	62
Table 3.8 Comparison of different classifiers usage.....	64
Table 3.9 Acceleration data for training and testing.....	65
Table 3.10 The experimental results using acceleration data without PCA process.....	69
Table 3.11 The experimental results using acceleration data with PCA process.....	71
Table 4.1 Image data for training and testing.....	84
Table 4.2 The experimental results using image data without PCA process.....	90
Table 4.3 The experimental results using image data with PCA process.....	91
Table 5.1 LRF data for training and testing.....	101
Table 5.2 Classification at different speeds.....	103

Table 5.3 The experimental results using downward LRF data without PCA process.....106

Table 5.4 The experimental results using downward LRF data with PCA process.....107

Table 6.1 The experimental results using forward LRF data.....110

Table 6.2 The values of variables.....119

Table 6.3 The numbers of samples before and after the MV.....124

Table 6.4 The comparison after using MRF multiple-sensor fusion.....129

ABSTRACT

Complete perception of the environment around a vehicle plays a crucial role in safe driving. Those include other stationary or dynamic objects, drivable regions, road signs and terrain types. In this thesis, classification of terrain types is investigated. Knowledge of the road terrain is useful to improve passengers' safety and comfort in road vehicles. It is also useful for bounding safe navigational routes for autonomous vehicles. Therefore, the aim of this thesis is to develop a methodology to identify impending road terrain types by using on-board sensors.

Two kinds of sensors are used in this research. The first kind of sensors measure parameters of the vehicle in terms of vibration and speed. Therefore, these sensors can only produce measurements while the vehicle is navigating on a particular terrain. The second type of sensors measure properties of the terrain in terms of structure and visual cues, for example cameras and Laser Range Finders (LRFs). These sensors can even produce measurements of impending terrain types. However, all those kinds of sensors have their own advantages and disadvantages. In this thesis, it is proposed to fuse them to improve the terrain type classification results.

The sensor fusion is achieved using Markov Random Field (MRF). The MRF model is designed to contain five nodes and five cliques which describe the relationships between the classification results of the accelerometer, camera, and two LRFs. The MRF model's energy function is appropriately synthesized to improve the classification accuracies of the impending terrains. Experiments carried out on a real vehicle test-bed, CRUISE (CAS Research Ute for Intelligence, Safety and Exploration) on different types of roads with

various speeds show that the MRF based fusion algorithm lead to significant improvements (approximate 30%) of the road terrain classification accuracies.

Keywords—road terrain classification, Markov Random Field, sensor data fusion, acceleration, image, Laser Range Finder