

Contents

Abstract	III
Kurzfassung	V
Nomenclature	IX
1 Introduction	1
1.1 State of the Art	1
1.1.1 Driver Assistance Systems	1
1.1.2 Environmental Sensors	2
1.1.3 Human Machine Interaction	4
1.1.4 Vehicle Guidance Control	6
1.1.5 Motion Planning	8
1.2 Thesis Contributions and Outline	14
2 Lateral Vehicle Dynamics	17
2.1 Reference Frames and Geometry	17
2.2 Tire Modeling	19
2.2.1 Tire Kinematics	19
2.2.2 Tire Forces: The Dugoff Model	21
2.3 Double-Track Model	26
2.3.1 Kinematics	26
2.3.2 Dynamics	27
2.4 Single-Track Model	29
2.4.1 Kinematics	30
2.4.2 Dynamics	31
2.5 Linear Single-Track Model	32
2.5.1 Vehicle-Fixed Formulation	33
2.5.2 Trajectory-Fixed Formulation	34
2.6 Steering Characteristics	36
2.6.1 Ackermann Steering	36
2.6.2 Self Steering Gradient	37
2.7 Model Validation with Experimental Data	41
2.7.1 Steady State Cornering Maneuver	43
2.7.2 Unsteady Cornering Maneuver	45
3 Potential Field based Motion Planning	49
3.1 Hazard Map	52
3.1.1 Road	52
3.1.2 Obstacles	56
3.1.3 Hazard Map Composition	60

3.2	Elastic Band	62
3.2.1	Equilibrium Configuration	62
3.2.2	Node Placement	65
3.2.3	Constraining Longitudinal Displacements	65
3.3	Cooperative Motion Planning	66
3.3.1	Driver's Steering Intention	67
3.3.2	Vehicle State Extrapolation	68
3.3.3	Driver's Maneuver Strategy	68
3.4	Algorithm and Computation	68
3.4.1	Distance Computation	70
3.4.2	Initial Solution	72
3.4.3	Equilibrium Solution	76
3.5	Simulations	76
3.5.1	Scenario I: Entering Traffic	78
3.5.2	Scenario II: Crossing Animal	80
3.5.3	Scenario III: Passing Maneuver with Oncoming Traffic	81
3.5.4	Pseudo Code of Motion Planning Algorithm	83
4	Potential Field based Vehicle Guidance Control	83
4.1	General Concept of Potential Field Guidance	85
4.2	Mapping a Virtual Guidance Force on Control Inputs	85
4.2.1	Nonlinear Mapping	86
4.2.2	Linear Mapping	87
4.3	Path Tracking Error	89
4.4	Guidance Kinematics	92
4.5	Guidance Dynamics	93
4.6	Stability Analysis and Controller Design	93
4.6.1	Lyapunov's Direct Method	94
4.6.2	Stability Analysis	97
4.6.3	Steady State Tracking Error	97
4.6.4	A Bound on the Tracking Error - Collision Avoidance	99
4.6.5	Sample Controller Design	101
4.6.6	Feedforward Control	103
4.7	Simulations	106
4.8	Comment on Human Vehicle Guidance	107
5	Shared Vehicle Guidance between Driver and Assistance System	107
5.1	Vehicle Guidance Control Loop	109
5.2	Driving Simulator Exploration	109
5.2.1	Haptic Human Machine Interface	111
5.2.2	Driving Simulator Setup	113
5.2.3	Lane-Keeping and Collision Avoidance Experiments	118
5.2.4	Results and Discussion	123
6	Conclusion	123
6.1	Summary	123
6.2	Future Work	124
	Appendix	125
	Bibliography	129