
Contents

Part I New concept of cooperation

1	Needs of improved assistant systems	3
1.1	Analysis of the cause of accidents on the road	3
1.2	Autonomous vehicles as possible solution	5
1.3	Ways for improving the driving safety	6
1.3.1	Improvement of the infrastructures	7
1.3.2	Improvement of the driver capacities	7
1.3.3	Improvement of the vehicles	7
1.4	Introduction of assistant systems and inherent problems	8
1.4.1	Current integration of assistant systems	8
1.4.2	New issues coming from assistant systems	9
1.4.3	Behavioral changes with the human supervision	9
1.4.4	Risks of complacency	9
1.5	Problem statement and improvements with SPARC	10
2	Adaptive cooperation between driver and assistant system	11
2.1	Vehicle architecture matching the driver cognition flow	11
2.2	Horizontal layering integrated into the vehicle	14
2.3	Overall presentation of the new concept	15
2.4	Presentation of the concept of adaptive cooperation	16

Part II Executive level as vehicle platform

1	Requirements for the executive level	23
1.1	Tasks of the executive level	23
1.2	Integration of the predictive vehicle dynamics model	24
1.2.1	Selection of methodology for the prediction of the vehicle dynamics	24
1.2.2	Integration of the predictive vehicle dynamics model	25

2	Road–tire μ friction coefficient estimation	27
2.1	Analysis of the current methodologies	27
2.2	Predictive camera-based measurement	28
2.2.1	Extraction of the ranges analysis	30
2.2.2	Statistical approach	30
2.2.3	Macroscopic approach	33
2.3	Local microphone-based measurement	40
2.3.1	Measuring the loud-speaker effect of the tire	40
2.3.2	Frequencies extraction from the collected data	41
2.3.3	Construction of models	43
2.3.4	Matching of the measures	45
2.4	Local control of the predictive measures	47
2.5	Pros and cons of the estimation methodology	48
3	Actuators and drive train architecture	51
3.1	Migration strategy to a full safe drive-by-wire platform	51
3.2	Drive train architecture	54
3.3	Electrical integration with mechanical back-up	55
3.4	Electrical replication	57
4	Vehicle dynamics model	59
4.1	Modeling of the actuators	59
4.1.1	Modeling the dynamics of a unit with a second-order transfer function	59
4.1.2	Non-iterative identification of the dynamics of units with continuous state	60
4.1.3	Identification of the dynamics of the retarder	62
4.1.4	Iterative identification of the gear and clutch dynamical model	62
4.1.5	Non-iterative identification of the differential model	67
4.2	Limitation due to electrical power	68
4.2.1	Model of maximal available energy	69
4.2.2	Optimizing the energy capacity	69
4.2.3	Modifying the command to adapt it to the energy level	70
4.2.4	Pre-compensation of the physical limitations	71
4.3	Dynamics model	72
4.3.1	Computation of the propulsive forces	73
4.3.2	Computation of the vehicle dynamics	74
4.4	Use of the dynamics model	75
5	Performing the vehicle command	77
5.1	Command range	77
5.2	Inverse computation of the actuators' command	79
5.3	Possible extension to a predictive command execution by use of transfer functions	80

5.4	Reactive optimization of the command	81
5.4.1	Longitudinal correction	81
5.4.2	Yaw rate correction with electronic stability control	84

Part III Virtual driver for the cooperation

1	Extended middleware for fault-tolerant architecture	91
1.1	Concept of software redundancy with a multi-agent system . . .	91
1.2	System management layer	93
1.2.1	Agent-based runtime environment	93
1.2.2	Use of a blackboard to provide information	95
1.2.3	Redundant management of the agents	97
1.3	Integration of fail-tolerant agents	103
1.3.1	Structure of an agent	103
1.3.2	Redundant computation	104
2	Agents derived from the robotic field	107
2.1	Potential field approach	107
2.1.1	Rejection forces	107
2.1.2	Lane keeping	109
2.1.3	Temporary destination setting	109
2.1.4	Resulting acceleration	109
2.1.5	Resulting problem	110
2.2	Modified dynamic window	111
2.2.1	Road monitoring	112
2.2.2	Object monitoring	113
2.2.3	Fusion of the two sub-modules	115
3	Tactic agent for speedway/highway	117
3.1	Fusion of reactive and anticipatory action	117
3.1.1	Environment categorization	118
3.1.2	Choice of the longitudinal and lateral controllers	120
3.2	Longitudinal controllers	121
3.2.1	Safety acceleration for the front direction	121
3.2.2	Distance control for the front direction	122
3.3	Lateral controllers	123
3.3.1	Safety range for the lane keeping	123
3.3.2	Extreme lane keeping assistant for other lanes	129
3.3.3	Safety distance for the lane changing	129
3.4	Anticipatory action to prevent inappropriate speed	131
3.4.1	Computation of the maximal safe speed	132
3.4.2	Extension to multiple paths	135

Part IV Adaptive cooperation

1	Methodology of a fault-tolerant adaptive cooperation	143
1.1	Drawbacks of current emergency brake	143
1.2	Concept of the adaptive cooperation	144
1.3	Functionalities degradation by use of recovery blocks	146
2	Understanding the driver maneuver	149
2.1	A priori choices by looking at the history	149
2.2	Weighting the choices with the command dynamics	151
2.3	Auto-adaptive detection	153
2.3.1	Analysis of the probabilistic graph of the maneuver detection	153
2.3.2	Updating the history	154
3	Determination of the driver drowsiness	155
3.1	Driver and his/her condition	155
3.2	Direct non-obtrusive measurement of the drowsiness	156
3.2.1	Methodology	156
3.2.2	Problem of reliability	157
3.3	Combination of multiple indirect measures	158
3.3.1	Simulation of test drives	158
3.3.2	From measures to indicators	160
3.3.3	Setting up of drowsiness references	162
3.3.4	Combination of the drowsiness indicators	163
3.3.5	Following the drowsiness evolution	164
4	Cooperation at the command level	167
4.1	Binary intervention	167
4.1.1	Concept of intervention	167
4.1.2	Meshing algorithm	168
4.1.3	Computation of the path transition	171
4.1.4	Transition control	173
4.1.5	Critical analysis	174
4.2	Fuzzy control	175
4.2.1	System confidence value	175
4.2.2	Adaptive weighting	176
4.2.3	Critical analysis	177
4.3	Adaptive cooperation	177
4.3.1	Concept of accepted dangerousness	178
4.3.2	Extension by use of the accepted dangerousness	178
4.3.3	Goal-based substitution process	181
4.3.4	Event-triggered intervention process	181

4.3.5	Fusion of both processes	183
4.4	Results and analysis	184
5	Feedback management for the driver and the virtual driver	185
5.1	Analogy to the delphi method	185
5.2	Detection of partial and full conflict situations	186
5.3	Feedback to the driver	188
5.3.1	Generation of a feedback for the driver	188
5.3.2	Different used channels	190
5.3.3	Feedback dispatching	191
5.4	Feedback to the virtual driver	194
5.4.1	Check of conflict due to lane detection	194
5.4.2	Check of conflict due to road-user detection	196
5.5	Critics on the new feedback extensions	203
Part V	Discussion on the proposed concept	
6	Concept summary and overview of the functionalities	207
6.1	Needs to help the driver in his/her task	207
6.2	New vehicle architecture concept	207
6.3	Creation of an extended executive level	208
6.4	Integration of a virtual driver	210
6.5	Concept of adaptive cooperation	211
6.6	Results and next steps	213
7	General conclusion	215
References		217
Index		225

