

---

# Contents

---

## Part I New concept of cooperation

---

<b>1</b>	<b>Needs of improved assistant systems</b>	<b>3</b>
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
<b>2</b>	<b>Adaptive cooperation between driver and assistant system</b>	<b>11</b>
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

---

<b>1</b>	<b>Requirements for the executive level</b>	<b>23</b>
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

<b>2</b>	<b>Road–tire <math>\mu</math> friction coefficient estimation</b>	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
<b>3</b>	<b>Actuators and drive train architecture</b>	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
<b>4</b>	<b>Vehicle dynamics model</b>	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
<b>5</b>	<b>Performing the vehicle command</b>	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

---

<b>1</b>	<b>Extended middleware for fault-tolerant architecture . . . . .</b>	<b>91</b>
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
<b>2</b>	<b>Agents derived from the robotic field . . . . .</b>	<b>107</b>
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
<b>3</b>	<b>Tactic agent for speedway/highway . . . . .</b>	<b>117</b>
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**


---

<b>1</b>	<b>Methodology of a fault-tolerant adaptive cooperation</b>	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
<b>2</b>	<b>Understanding the driver maneuver</b>	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
<b>3</b>	<b>Determination of the driver drowsiness</b>	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
<b>4</b>	<b>Cooperation at the command level</b>	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
<b>5</b>	<b>Feedback management for the driver and the virtual driver</b>	<b>185</b>
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
<hr/>		
<b>Part V</b>	<b>Discussion on the proposed concept</b>	
<hr/>		
<b>6</b>	<b>Concept summary and overview of the functionalities</b> .....	<b>207</b>
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
<b>7</b>	<b>General conclusion</b> .....	<b>215</b>
<b>References</b>	.....	<b>217</b>
<b>Index</b>	.....	<b>225</b>





<http://www.springer.com/978-3-540-74473-3>

Adaptive Cooperation between Driver and Assistant  
System

Improving Road Safety

Holzmann, F.

2008, XIII, 225 p., Hardcover

ISBN: 978-3-540-74473-3