

Contents

Preface	xv
List of Contributors	xvii
Acknowledgments	xix
PART 1 INTELLIGENT TRANSPORT SYSTEMS	1
1 Introduction to Intelligent Transport Systems	3
<i>C O Nwagboso</i>	
1.1 Introduction	3
1.2 Intelligent Transport Systems	4
1.2.1 European Union Initiatives	5
1.2.2 US Initiatives	10
1.2.3 Japanese initiatives	13
1.3 Elements of Intelligent Transport Systems	21
1.3.1 Traffic Management and Control	21
1.3.2 Public Transport and Freight Operation Systems	22
1.3.3 Mobile Telecommunications Systems	23
1.3.4 Debiting and Smart Card Systems	24
1.3.5 User Information Systems	26
1.3.6 Advanced Vehicle Safety Systems	26
1.4 Intelligent Transport Systems User Requirements	28
1.4.1 Public Transport	29
1.4.2 Freight Operators	29
1.4.3 Fleet/Freight Drivers	30
1.4.4 Private/Individual Users	30
1.4.5 Network Operators	30
1.5 Conclusions	31

2	Microprocessor-based Control Technique for Vehicle Performance Optimization	33
	<i>S R Vishnubhotla</i>	
2.1	Introduction	33
2.2	Preliminaries	34
2.2.1	Sensors and Actuators	35
2.2.2	A/D and D/A Converters	36
2.2.3	Multiplexing, Demultiplexing and Buses	36
2.2.4	Multiprocessor Architecture	38
2.3	Vehicle Control and Diagnostics	40
2.3.1	Control Parameters	40
2.3.2	Controls	41
2.3.3	Diagnostics	42
2.4	Small Vehicles	42
2.4.1	Analysis of the Parameters	43
2.4.2	Control of Body Parameters	44
2.4.3	Control of Engine/Dynamic Parameters	45
2.5	Complex Vehicles	46
2.5.1	Description of the System	47
2.5.2	Operation of the System	47
2.6	Future Automobiles	49
2.7	Conclusions	49
3	Automotive Electronic Trends and their Influence on Intelligent Transport Systems	53
	<i>B F Heinrich</i>	
3.1	Introduction	53
3.2	Automotive Electronics Trends	54
3.2.1	Historical Trends	55
3.2.2	Present Trends	57
3.2.3	Future Trends	61
3.3	Technology Push Versus Market Pull	66
3.4	Intelligent Vehicle-Highway Systems Deployment	67
3.5	Driver Acceptance	70
3.6	Conclusions	71
PART 2	DYNAMICS OF INTELLIGENT VEHICLES	73
4	Intelligent Vehicle Systems and Control	75
	<i>C O Nwagboso</i>	
4.1	Introduction	75
4.2	Vehicle Electronics and Control	77
4.2.1	Vehicle Sensors	78
4.2.2	Basic Control Systems Technology	87
4.2.3	Vehicle Following	94
4.3	Collision Avoidance Systems	97

4.4	Cruise Control System	100
4.4.1	Intelligent Cruise Control System	101
4.5	Navigation and Route Guidance Systems	103
4.5.1	Vehicle Navigation Systems	104
4.5.2	Dynamic Route Guidance Systems	115
4.6	Communication Systems	117
4.7	Driver Vision Enhancement	120
4.8	Conclusions	122
5	Intelligent Automotive Systems: Development in Full-time Chassis Motion Spheres for Intelligent Vehicles	125
	<i>B T Fijalkowski</i>	
5.1	Introduction	125
5.2	Proof-of-concept full-time 4WS × 4WA × 4WD × 4WB Intelligent Road Vehicles	126
5.3	Purpose of Integrated IRV Motion Control Between Individual 4WS, 4WA, 4WD and 4WB Controls	128
5.3.1	Dual-Mode Hybrid 4WS Conversion Sphere	131
5.3.2	Predictive and Adaptive 4WA Suspension Sphere	134
5.3.3	Series Hybrid 4WD Propulsion Sphere	136
5.3.4	Anti-wheel-lock and Anti-wheel-spin 4WB Dispulsion Sphere	140
5.4	Conclusions	141
6	Trends in Traction Control for Improved Vehicle Dynamics	143
	<i>S Shiraishi, O Yamamoto, K Kin and Y Akuta</i>	
6.1	Introduction	143
6.2	History of Traction Control Systems	144
6.3	Recent Trends in Traction Control	146
6.3.1	Nissan ETS System	147
6.3.2	Porsche Tiptronic System	148
6.3.3	Mitsubishi TCL System	148
6.3.4	Honda TCS System	151
6.4	Fundamental Form of Traction Control	151
6.5	Classification of Types of Traction Control	153
6.6	Hierarchical Relationships in Traction Control Systems	155
6.7	Harmonizing Traction Control with Other Systems	158
6.8	Conclusions	165
PART 3	AUTONOMOUS VEHICLES SYSTEMS	167
7	A Closed-loop Four-wheel-steering Control System: Toward an Autonomous Vehicle	169
	<i>E C Yeh, R H Wu and J C Hsu</i>	
7.1	Introduction	169
7.2	4WS Control System	170
7.2.1	An Overview of the 4WS Control System	170
7.2.2	A Multi-input 4WS System	172

7.3	The Closed-loop 4WS Control System Towards an Autonomous Vehicle	181
7.3.1	Intelligent Control Centre	183
7.3.2	Closed-loop 4WS Vehicle System	185
7.3.3	Environment Sensing System	185
7.3.4	On-board Monitoring and Emergency Handling	186
7.4	Future Prospects for the Steering Control System	186
7.5	Conclusions	187
8	Collision-free Manoeuvring and Control for an Autonomous Vehicle	189
	<i>K I Trovato</i>	
8.1	Introduction	189
8.2	Framework	189
8.3	Algorithm Analysis and Accuracy	193
8.4	The Fire Exit Problem	194
8.5	The Robot Path Planning Problem	195
8.6	The Vehicle Manoeuvring Problem	196
8.7	A Forward-only Constraint	201
8.8	Use of the System for Complex Manoeuvres and Larger Areas	201
8.9	A Radio-controlled Example	203
8.10	High-speed Vehicle Manoeuvring	205
8.11	Invitation	206
8.12	Conclusions	206
9	Optically-based Underground Mine Vehicle Guidance	209
	<i>R Hurteau, Y Laperriere and M St Amant</i>	
9.1	Introduction	209
9.1.1	Mine Context	210
9.1.2	Automation of Ore Transportation	211
9.2	Description of the System	213
9.2.1	Demonstration Prototype	216
9.3	Optical Detector	217
9.3.1	Guideline and Milestones	217
9.3.2	Guideline Detector	219
9.3.3	Image Analysis	219
9.3.4	Geometrical Model of the Optical Detector	221
9.3.5	Navigation Errors	223
9.3.6	Performance	224
9.3.7	Simulation of the Optical Detector	225
9.4	Motion Control of the Vehicle	227
9.4.1	Model of the Vehicle	227
9.4.2	Design Model and Motion Controller	229
9.4.3	Speed Controller	231
9.4.4	Position Orientation Controller	231
9.5	Simulation and Experimental Results	233
9.5.1	Gain Adaptation with the Speed	233
9.5.2	Tracking Properties	235

9.6	Test on a Load Haul Dump Vehicle	239
9.7	Conclusions	241
10	Application of Neural Networks to Guidance of Autonomous Vehicles	243
	<i>A S Pandya and P G Luebbbers</i>	
10.1	Introduction	243
10.2	Autonomous Land Vehicle Application	245
10.3	Design Rationale	246
	10.3.1 Determination of Road from Non-road Portions of Image Data	247
	10.3.2 Determination of Guidance Controller	247
	10.3.3 A General Framework for an Autonomous Land Vehicle Control System	248
10.4	Description of Neural Network/Fuzzy Logic Controller for HMMWV	249
	10.4.1 Edge Extraction and Edge Modelling	250
	10.4.2 Feature Extraction	250
	10.4.3 Feature Extraction Results	252
	10.4.4 Neural Network Feature Approximation Results	252
	10.4.5 Neural Network/Fuzzy Logic Controller	252
10.5	Conclusion	256
PART 4	VEHICLE NAVIGATION AND GUIDANCE	259
11	Camera Telemeter Multisensory System for Obstacle Avoidance	261
	<i>J Trassoudaine, J Gallice and F Collange</i>	
11.1	Introduction	261
11.2	The Multisensor	262
	11.2.1 Description and Performances of the Multisensor	262
	11.2.2 The Multisensor Calibration	267
	11.2.3 A Smart Sensor	272
11.3	Obstacle Detection and Tracking by a Multisensorial Approach	277
	11.3.1 Obstacle Detection	277
	11.3.2 Obstacle Tracking	279
	11.3.3 Results	283
11.4	Conclusion	284
12	Trends in Vehicle Navigation and Guidance Systems for Intelligent Motoring	289
	<i>A M Parkes</i>	
12.1	Introduction	289
12.2	Route Planning	291
12.3	Route Navigation	291
12.4	Route Guidance	291
12.5	Conclusions	300

13	Simulation Modelling of Route Guidance Control Strategies	303
	<i>N B Hounsell and A Stevens</i>	
13.1	Introduction	303
13.1.1	Development of Dynamic Route Guidance	303
13.1.2	Control Strategies	304
13.1.3	The Need for Simulation Modelling	305
13.2	Simulation	305
13.2.1	Simulation Requirements	305
13.2.2	Simulation Options	306
13.2.3	Developments of Contram	307
13.2.4	Model Features and Applications	309
13.3	Conclusions	316
PART 5	INFORMATICS SYSTEMS	319
14	Development of Safe Road Transport Informatic Systems	321
	<i>H Trier and G Heuser</i>	
14.1	Introduction	321
14.2	Notes on Terminology	322
14.2.1	Choice of Jargon	322
14.2.2	Fault, Error, Failure	323
14.2.3	Verification and Validation	323
14.3	The Safety Task Force	324
14.4	Systems Consideration	325
14.4.1	Definition of Systems	325
14.4.2	Systems Configuration	325
14.4.3	Systems Safety Considerations	326
14.5	Process of Integrity Level Assignment	330
14.5.1	Hazard Identification and Specification	330
14.5.2	Assignment of Controllability Category and its Integrity Level	331
14.6	Approach to Attain Safety	332
14.7	Safety Requirements	333
14.8	Consideration of Failure	333
14.9	Measures Against Failure	334
14.9.1	Measures to Avoid Failures	336
14.9.2	Measures to Control Faults	337
14.9.3	Fault Detection Measures	338
14.9.4	Effectiveness of Measures	341
14.10	Assignment of Measures to Integrity Levels	341
14.11	Conclusion	341
15	Information Systems for Public Transport Management	343
	<i>B De Saint-Laurent</i>	
15.1	Introduction	343
15.1.1	Scope and Contributions	343
15.1.2	Some Definitions	343

15.2	What is an Advanced Public Transport System?	344
15.2.1	The APTS Rationale: Where Supply Meets Demand	344
15.2.2	The APTS Response	345
15.2.3	Achievements of APTS so far	349
15.2.4	Evaluation of APTS Impact	349
15.2.5	Limits of Existing Systems	350
15.2.6	New Issues	358
15.3	Computer-based Advanced Solutions	358
15.3.1	The Cassiope/EuroBus/Transmodel Framework in Drive	358
15.3.2	Implementation Aspects	359
15.3.3	Other Needs for Standardization	366
15.4	A Vital Issue for Public Transport	366
16	Analysis of Road Database Management Structure	371
	<i>Y Loyaerts</i>	
16.1	Introduction	371
16.2	Road Database Information	372
16.2.1	Data Levels	372
16.2.2	Data Domains of a Road Database	373
16.2.3	Network Definition	375
16.3	Data Collection	376
16.4	Data Quality	377
16.4.1	Quality of Information Collection	377
16.4.2	Quality of Database Updating	378
16.4.3	Quality During Exchange of Information	379
16.5	Distribution of Road Data	379
16.5.1	Road Databases Interested Parties	380
16.5.2	Road Reference System	381
16.5.3	Neighbouring Data	382
16.6	Data Exchange	382
16.6.1	Liaison with Other Bodies	383
16.6.2	Data Exchange	384
16.7	The Way Forward	385
16.7.1	Future Actions	385
16.8	Conclusions	387
PART 6	AUTOMATED TRAFFIC CONTROL SYSTEMS	391
17	Video Image Understanding for Automatic Traffic Monitoring and Control	393
	<i>A Rourke and M G H Bell</i>	
17.1	Introduction	393
17.2	Practicalities of Image Processing for Traffic Monitoring	394
17.3	Loop Emulation	397
17.3.1	The TULIP System	398
17.3.2	Results of TULIP Processing	399
17.4	Queue and Congestion Monitoring Using Image Processing	400
17.4.1	The Fast-Q System	401
17.4.2	Experimental Results	404

17.5	Vehicle Classification	405
17.5.1	Model Creation	406
17.5.2	Three-dimensional Modelling	407
17.5.3	Camera Calibration	408
17.5.4	Vehicle Modelling	410
17.5.5	Model Construction	410
17.5.6	Image Segmentation	411
17.5.7	Model-image Matching for Vehicle Classification	412
17.6	Conclusions	414
18	Automatic Vehicle Model Classification	417
	<i>M Varga and J Radford</i>	
18.1	Introduction	417
18.2	Region Cueing Algorithm	417
18.2.1	Edge Extraction	418
18.2.2	Line Type Fractal Discriminant	418
18.2.3	Circle/Arc Finding Hough Transform	419
18.2.4	Wheel-base Detection	419
18.2.5	Pre-processing	420
18.3	Model Classification	420
18.3.1	Data Representation	420
18.3.2	Dynamic Programming	420
18.3.3	Edge Based Classification	421
18.3.4	Modification of the Edge-based Classification	423
18.4	Experimental Set-up	425
18.5	Conclusions	425
19	Model Based Collaboration Architectures for Traffic Control	433
	<i>M Irgens, C Krogh and H Traettebers</i>	
19.1	Introduction	433
19.2	Methodological Preliminaries	434
19.3	The Problem: a Brief Analysis	434
19.4	Solution Elements: the Models	436
19.4.1	Abstraction and Granularity	436
19.4.2	Imperative and Declarative Elements	436
19.4.3	Imperative Elements	437
19.4.4	Declarative Elements	440
19.5	Model-based Collaboration: Architectures	444
19.5.1	Requirements	444
19.5.2	A Model-based Architecture	445
19.5.3	A Generic Tasks Architecture	446
19.5.4	A Blackboard-based Architecture	448
19.5.5	Cooperating Supervised Agents	449
19.6	Solution Elements Instantiated: IUTCS and KITS	451
19.7	Conclusion	452

20	Application of Artificial Intelligence and Expert Systems to Traffic Control	455
	<i>G Ambrosino, M Bielli and M Boero</i>	
20.1	Introduction	455
20.2	Knowledge-based and Expert Systems Approach to Traffic Control	456
	20.2.1 Current Problems with Conventional UTC Technology	456
	20.2.2 Roles	458
	for Knowledge-based Techniques in Urban Traffic Control Systems	
20.3	A Knowledge-based Architecture for Traffic Control	459
	20.3.1 The Blackboard Approach	460
	20.3.2 The IUTCS Architecture	461
	20.3.3 The knowledge sources	462
	20.3.4 Knowledge Representation	466
20.4	Testing the IUTCS Prototype	467
	20.4.1 Testing Traffic Data Inference Agent	468
	20.4.2 Testing the Traffic Control Agent	469
20.5	Conclusions	471
21	Application of a Neural Network with Computer Vision for a Vehicle Identification and Detection System	475
	<i>K Kanayame and T Naito</i>	
21.1	Introduction	475
21.2	Image Processing for Traffic Applications	476
21.3	Vehicle Identification System	477
	21.3.1 Extraction of Plate Character String and Cut-out of Character	477
	21.3.2 Normalization and Image Transfer	477
	21.3.3 Character Recognition by the Neural Network	478
21.4	Vehicle Detection System	480
	21.4.1 Pre-processing for a Vehicle Detection System	480
	21.4.2 Image Analysis by the Neural Network for a Car Detection System	481
21.5	Conclusions	487
	Subject Index	489