IEEE Intelligent Vehicles Symposium

Alcalá de Henares 2012

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About IV 2012

THE INTELLIGENT VEHICLES SYMPOSIUM (IV'12) is the premier annual forum sponsored by the **IEEE INTELLIGENT TRANSPORTATION SYSTEMS SOCIETY (ITSS)**. Researchers, academicians, practitioners, and students from universities, industry, and government agencies are invited to discuss research and applications for Intelligent Vehicles and Vehicle-Infrastructure Cooperation. The technical presentations are characterized by a single session format so that all attendees remain in a single room for multilateral communications in an informal atmosphere. Tutorials will be offered on the first day followed by three days of presentations and a vehicle demonstration day. An exhibition area will be available for the presentation of products and projects, as well as for small demonstrations.

Program topics include but are not limited to:

- Advanced Driver Assistance Systems
- Automated Vehicles
- Vehicular Safety, Active and Passive
- Vehicle Environment Perception
- Driver State and Intent Recognition
- Eco-driving and Energy-Efficient Vehicles
- Impact on Traffic Flows
- Cooperative Vehicle-Infrastructure Systems
- Collision Avoidance
- Pedestrian Protection
- V2I / V2V Communication
- Assistive Mobility Systems
- Intelligent Ground, Air and Space Vehicles
- Autonomous / Intelligent Robotic Vehicles
- Image, Radar, Lidar Signal Processing
- Information Fusion
- Vehicle Control
- Telematics
- Human Factors and HMI
- Electric and Hybrid Technologies
- Novel Interfaces and Displays
- Intelligent Vehicle Software Infrastructure

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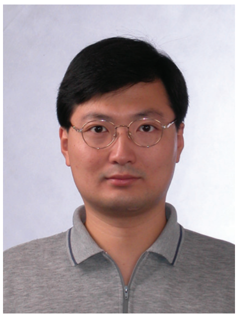

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Chair Messages

Miguel Ángel Sotelo

General Chair

Intelligent Vehicles: from safety to sustainability

Dear Colleagues:

On behalf of IV'12 Organizing Committee it is my pleasure and honor to give you our warmest welcome to the 2012 IEEE Intelligent Vehicles Symposium in Alcalá de Henares, Spain. The scope and application of intelligent vehicles technologies have dramatically evolved since the first IV conference celebrated in Tokyo, in 1990. Along the 22 years of history of IV conferences, the automobile has suffered an extraordinary metamorphosis from being the key element in road safety and autonomous driving to becoming the cornerstone in transport sustainability and energy efficient policies worldwide. Accordingly, Intelligent Vehicles have adapted their technological features in order to achieve full connectivity (vehicle-to-vehicle, vehicle-to-infrastructure, vehicle-to-road user), to become eco-friendly and, in a few words, to get socially and economically valuable and acceptable. In this rapidly changing and global scenario, the Intelligent Vehicles scientific and industrial community has demonstrated to be part of the solution. It is a privilege for us to host the Intelligent Vehicles Symposium in Spain for the first time in the history of IV conferences, particularly now that Spanish industry is being revitalized by new developments in the automotive sector. These developments encompass a mixture of sustainable technologies and intelligent devices that make the new car models authentically unique and specially adapted to the new requirements of safety, sustainability and energy efficiency in urban transportation and logistics. I really hope that IV'12 will help to draw significant conclusions on these issues.

I want to thank our Program Chair, Meng Lu, for her generous dedication and full commitment to IV'12. Under her leadership, the International Program Committee has developed a high quality technical program including all the topics already mentioned. Matthew Barth and Ljubo Vlacic, as Program Co-Chairs, supported her during the review process and program planning. You will have the opportunity to participate in one of our six workshops on Sunday, June 3rd, just before the main technical program starts. These include (1) The First International Workshop on IPv6-based Vehicular Networks (Vehi6), (2) Workshop on Human Factors in Intelligent Vehicles, (3) Workshop on Navigation, Accurate Positioning and Mapping for Intelligent Vehicles, (4) Advances in Heavy Vehicle Safety, Energy Efficiency, and Controls, (5) Perception in Robotics and (6) Ambient Intelligence for Tomorrow's Intelligent Transportation Systems. Rafael Toledo, our Workshop and Tutorial Chair, has organized this event.

Regarding the non-technical activities we will take you to some of the historical sites of Alcalá de Henares. On Monday evening, we will come together for a reception at the Paraninfo, a historical room where the ceremony of the prestigious Cervantes's Award takes place every year chaired by his Majesty the Spanish King. After that, we will share some drinks and traditional dishes in the Patios of the University of Alcalá. On Tuesday evening we will have the banquet dinner in the Hotel El Parador, another historical site in Alcalá de Henares that has been recently rehabilitated as a luxury hotel.

A demonstrations day will be offered on Thursday, showing the latest developments in intelligent vehicles technologies from industry and academia. José Eugenio Naranjo and José María Armingol have organized this event as Demonstration Co-chairs. María Teresa de Pedro, Luis Miguel Bergasa, Jonas Sjöber, Ming Yang, Sebastián Sánchez Prieto, David Fernández Llorca and Miguel Ángel García Garrido complete the IV'12 Organizing Committee. Without their generous contribution, the organization of this conference would have been simply impossible. Let me also express my utmost gratitude to the task force of volunteers that have supported IV'12, such as keynote speakers, editors, reviewers, sponsors, demonstrators, exhibitors, technical staff and, of course, the attendees. You, authors, are definitely the soul of the conference.

Enjoy your stay in the historical city of Alcalá de Henares, home to the Romans in ancient times, cradle of Miguel de Cervantes, the greatest Spanish writer in history, and in 2012, for a few days, the world capital of the Intelligent Vehicles.

Yours,

Miguel Ángel Sotelo
General Chair. IEEE IV 2012

Full Professor
University of Alcalá (UAH), Spain

Meng Lu

Program Chair

Dear Colleagues,

As the Program Chair of IEEE IV 2012, I am very pleased to welcome you to the conference in Alcalá de Henares, Spain. The Program Committee has organised a technical program encompassing around 200 contributions, which offers a broad insight into both the state of the art and the future of intelligent vehicles. As for previous IV conferences, a single-track format is used. More than 80% of the papers will be presented as posters in six multidisciplinary poster sessions. Eight oral sessions focus on current research topics, e.g. driver assistance systems, cooperative vehicle-highway systems, vehicle environment perception, automated vehicles and collision avoidance, sensor technologies and active and passive safety. We have the great privilege of welcoming three distinguished keynote speakers, who will provide their view on realizing self-driving vehicles, smart cars for safe pedestrians, and toward environmental sustainability in a connected world. In addition, the program includes a panel discussion on autonomous driving featuring five distinguished experts, who will address the many challenges of this topic.

I would like to thank everyone who contributed to the program for their enthusiastic involvement and substantial efforts. I would especially like to acknowledge my colleagues of the Program Committee (the Associate Editors), of the Organizing Committee, and of the Awards Committees, for their kind support during the review process, the program preparation, and the selection of the best papers. Special thanks go to all the reviewers for their substantial contributions. Last but certainly not least, a special word of thanks to Pradeep Misra for providing prompt and extensive technical support and very kind help.

For all IV 2012 participants, I hope that this conference will provide you with a unique chance to extend your knowledge, to enhance your network, to generate new ideas, and to establish or strengthen valuable contacts and friendships. Enjoy your stay in beautiful Alcalá de Henares. Its historical centre is one of UNESCO's World Heritage Sites.

盧萌

Dr. Meng Lu
Program Chair, IEEE IV 2012

Program Manager International
Dutch Institute for Advanced Logistics. The Netherlands

IEEE IV 2012

Keynote Speakers

Chris Urmson

Keynote Speaker – Monday 9:00

Realizing Self-Driving Vehicles

Affiliation: Head of Engineering – Self Driving Car
Google Inc.
Mountain View, USA

Abstract: Self-driving vehicles hold the promise of uncrashable vehicles and reshaping our relationship with the automobile. The Google Self-Driving car project was created to rapidly advance autonomous driving technology. Building from the foundation of decades of research and the DARPA Challenges, we have developed a small fleet of autonomous self-driving vehicles. In this talk, I will provide an introduction to the work Google has been doing in advancing the state-of-the art in autonomous vehicles. To drive autonomously the vehicles use a combination of prior map data and on-line sensing. Prior to driving autonomously, we map the area using the sensors on one of our vehicles. On line, the vehicles use this model to estimate their position and to help them track objects that move through the world (pedestrians, cyclists, cars, etc.). The motion planner then combines the a priori model of where the roads are with the objects that are detected online to determine safe trajectories through the world. In the course of the talk, I will demonstrate the capabilities (and limitations) of our vehicles, and talk briefly about the future of autonomous driving.

Bio: Chris Urmson is the head of engineering for Google's self-driving car program and is an adjunct professor at Carnegie Mellon University. Chris was the Director of Technology for the team that won the 2007 DARPA Urban Challenge. He has developed several robotic navigation architectures and software systems currently in use by Carnegie Mellon University, NASA JPL and NASA Ames. He earned his PhD in 2005 from Carnegie Mellon and his B.Sc. in Computer Engineering from the University of Manitoba in 1998.

Dariu M. Gavrila

Keynote Speaker – Tuesday 9:00

Smart Cars for Safe Pedestrians

Affiliation: Senior Research Scientist
Daimler R&D
Ulm, Germany

Abstract: One of the most significant large-scale deployment of intelligent systems in our daily life nowadays involves driver assistance in smart cars. The past decade has seen a steady increase of interest in the plight of the vulnerable road users (e.g. pedestrians, bicyclists), motivated by accident statistics, and accentuated by regulatory and consumer rating initiatives. Devising an effective driver assistance system for vulnerable road users has long been impeded, however, by the "perception bottleneck", i.e. not being able to detect and localize vulnerable road users sufficiently accurate. In this talk, I give an overview of the remarkable research progress that has been achieved in this area. I discuss its main enablers and highlight future developments, on the road towards accident-free driving.

Bio: Dariu M. Gavrila received the Ph.D. degree in computer science from the University of Maryland at College Park in 1996. Since 1997, he has been a Senior Research Scientist at Daimler R&D in Ulm, Germany. In 2003, he was appointed professor in the Faculty of Science at the University of Amsterdam, chairing the area of Intelligent Perception Systems (part time). Over the last decade, Prof. Gavrila has addressed perception systems for detecting humans and their activity. He particularly focused on active pedestrian safety, where was responsible for several EU and German projects on behalf of Daimler (PROTECTOR, SAVE-U, WATCH-OVER, AKTIV). He wrote a sizeable number of highly cited publications and received the I/O 2007 Award from the Netherlands Organization for Scientific Research (NWO), as well as several conference paper awards. His personal website is www.gavrila.net.

Robert L. Bertini

Keynote Speaker – Wednesday 9:00

Toward Environmental Sustainability in a Connected World

Affiliation: Professor. Civil and Environmental Eng.
Portland State University
Portland, Oregon, USA

Abstract: Typically the improvement of safety and mobility/efficiency are the prime goals of transportation policies, programs, projects and technologies. More and more the concept of "environmental sustainability" has crept onto the scene as a third priority. There are different approaches across world regions toward making firm sustainability goals--the EU has its White Paper while the U.S. efforts are distributed across state and local agencies. This keynote address will explore environmental sustainability as a critical component of our research and development of intelligent vehicle and roadside solutions. As we anticipate and develop new technologies in vehicles and on the roadside, and bring these two worlds together in a truly connected future, what opportunities do we have to achieve progress toward environmental sustainability? How do sustainability benefits overlap with safety and mobility benefits? How can we in the transportation field contribute our fair share toward sustainability goals? What research and policy challenges remain for us to tackle moving forward?

Bio: Dr. Robert L. Bertini is Professor of Civil & Environmental Engineering at Portland State University in Portland, Oregon, USA, and is spending the 2011-2012 academic year as Visiting Professor at the Delft University of Technology in the Netherlands. Bertini most recently served as a political appointee in the Obama Administration as the fourth and longest-serving Deputy Administrator of the Research and Innovative Technology Administration (RITA) at the U.S. Department of Transportation. Dr. Bertini also served as Acting Director of the Intelligent Transportation Systems Joint Program Office from 2010-2011. At the U.S. DOT, Bertini led transportation workforce development and employee ideation community initiatives and was a champion for international cooperation and multimodal collaboration. He was the founding Director of the Oregon Transportation Research and Education Consortium (OTREC), a National University Transportation Center that is a partnership among Portland State University, the University of Oregon, Oregon State University and the Oregon Institute of Technology. Bertini developed and directed the Intelligent Transportation Systems (ITS) Laboratory at Portland State and was the recipient of the National Science Foundation (NSF) CAREER Award. Bertini is a registered professional engineer in Oregon and California with more than 23 years' experience in the transportation field, including work with local government, several national transportation consulting firms on transit and highway projects, the auto industry, and university research and education. Professor Bertini is a sought-after speaker, lecturer and facilitator on transportation, leadership and collaboration topics, and is the author or co-author of more than 230 publications, including journal articles, conference proceedings, book chapters and technical reports. He is the chair of the National Academies' Transportation Research Board Committee on Traffic Flow Theory and Characteristics (AHB45) which also oversees the Joint Subcommittee on Traffic Simulation Models. A former city planning commissioner, Bertini earned a B.S. cum laude in Civil Engineering from the California Polytechnic State University, San Luis Obispo; an M.S. in Civil Engineering from San Jose State University, and a Ph.D. in Civil Engineering from the University of California at Berkeley. Email: bertini@pdx.edu. Web: web.pdx.edu/~bertini.

IEEE IV 2012

Workshops

The First International Workshop on IPv6-based Vehicular Networks (Vehi6)

Sunday 9:30 ***Room 1***

Organizers: José Santa
(University of Murcia)
Jong-Hyouk Lee
(INRIA)

Abstract: Wireless vehicular networking for cooperative ITS is one of the most interesting and active research topics, which requires vital efforts from both the industry and the academia. IPv6 has been acknowledged as a masterpiece to support services such as traffic efficiency, leisure applications and non-time critical safety services. In this frame, the objective of this workshop is to provide a forum to exchange ideas, present results, share real experiences or exploring the current state of the art, on the application of IPv6 in vehicular network architectures, prototypes, test beds or commercial products in the field of intelligent transportation systems. Original papers addressing either scientific or engineering aspects about IPv6 integration in wireless vehicular networking for cooperative ITS are welcome. Papers describing or evaluating approaches for network and facilities/middleware levels are especially considered.

Web site: http://ants-webs.inf.um.es/conferences/vehi6/

Workshop on Human Factors in Intelligent Vehicles

Sunday 14:30 Room 3

Organizers: Cristina Olaberri
(Institute of Ergonomics. Technische Universität München)
Rosaldo Rossetti
(University of Porto)

Abstract: The Workshop on Human Factors in Intelligent Vehicles (HFIV'12) aims to foster discussion on issues related to the analysis of human factors in the design and evaluation of intelligent vehicles (IV) technologies, in a wide spectrum of applications and in different dimensions. It is expected to build upon a proper environment to disseminate knowledge and motivate interactions among the technical and scientific communities, practitioners and students, allowing state-of-the-art concepts and advances to be further developed and enhanced. IV technologies have experienced a great improvement in the last couple of decades, turning vehicles into more interactive counterparts in transportation and mobility systems. However, the impact of such technologies on traffic awareness for the driver and driver's behavior towards improving driving performance and reducing road accidents still demands proper tools and approaches. While the feasibility of incorporating new technology-driven functionality to vehicles has played a central role in the automotive design, not always safety issues related to interaction with the new in-vehicle systems have been taken into consideration. Additionally, other aspects are equally important and need to be analyzed, such as the impact technologies that support specific driving functions play on the overall driving task, as well as their impact on the transportation system overall performance. Besides current industrial achievements that feature today's vehicles with a number of important driving assistance systems, the perspective of autonomous driving vehicles populating urban environment pose even more challenging issues. Thus, the information and functionality that relies on new ways of communication has to be presented in a non-intrusive way that complies with specific design requirements. A system that guarantees efficiency of use, comfort and user satisfaction can contribute to a more conscious driving behavior that would directly result from the adoption of IV technologies.

Workshop on Human Factors in Intelligent Vehicles

Some topics of interest include (but are not limited to) the following:

- Intelligent user interfaces
- Human-machine interaction
- Human-in-the-loop simulation
- Cognitive aspects of driving
- Human behavior and capability, affecting system's design and operation
- Modeling and simulation in driver's behavior analysis
- Tools and approaches to analyze human factors
- Ergonomics of traveler information systems
- Behavioral elicitation and influence
- Anthropometric layout of vehicular technical systems
- Methodologies to optimize overall system performance
- Mixed Reality
- Cross-Cultural Design
- Augmented Cognition
- User Experience and Usability
- Computer Aided Ergonomics Analysis
- Cognitive Modeling
- Effects of in-vehicle systems on driver performance
- Tools and methodologies for usability assessment
- Input/Output modalities in system ergonomic design

Web site: http://www.dcc.fc.up.pt/HFIV12/

Workshop on Navigation, Perception, Accurate Positioning and Mapping for Intelligent Vehicles

Sunday 9:30 *Room 2*

Organizers: David Bétaille
(IFSTTAR Nantes)
Vicente Milanés
(University of California Berkeley)
Jorge Villagrá
(CAR UPM-CSIC)
Rafael Toledo-Moreo
(Universidad Politécnica de Cartagena)
Juan Nieto
(University of Sidney)
Martin Adams
(Universidad de Chile)
Eduardo Nebot
(University of Sidney)

Abstract: The workshop is soliciting papers that focus on novel theoretical approaches or practical applications of autonomous navigation, perception, accurate positioning and mapping for intelligent vehicles in real and complex environments. The topics include, but are not limited to, advances in the following areas:

- GNSS-based navigation
- Multi-sensor integration
- Filtering techniques for positioning
- Map-matching and map-aided location
- Lane Detection, Lane keeping and Lane-level applications
- Autonomous navigation and guidance
- Autonomous vehicle cooperation
- Cooperative maneuvers
- Unmanned vehicle interaction
- Environment perception

Workshop on Navigation, Perception, Accurate Positioning and Mapping for Intelligent Vehicles

- Road safety applications
- Reliability-critical applications
- Vehicle and Pedestrian detection
- Collision detection and avoidance
- Driver assistance
- Road detection
- Environment representation
- Automatic cruise control systems
- Cooperative Perception
- 3D reconstruction
- New Perception Sensors

In-depth analyses of the state of the art are also encouraged for submission.

Web site: http://iv2012-poma.ifsttar.fr/index.php

Advances in Heavy Vehicle Safety, Energy Efficiency, and Controls

Sunday 10:00 Room 4

Organizers: Hocine Imine
(LEPSIS/IFSTTAR Paris)
Dongpu Cao
(Lancaster University)

Abstract: This workshop focuses on recent research and development advances in heavy vehicle system modeling, dynamics and stability, and chassis and powertrain controls, contributing to the enhanced vehicle dynamics and safety, energy efficiency, and intelligent transportation systems. Topics related to both on- and off-road heavy vehicles will be considered, while the cost-effective technologies will be particularly explored. The workshop also welcomes contributions regarding regulatory outlook on the topics of heavy vehicle systems and road safety.

Web site: http://iv2012-ahvec.ifsttar.fr/

Perception in Robotics

Sunday 9:00 *Room 3*

Organizers: Luis Miguel Bergasa
(University of Alcalá)
Rafael Barea
(University of Alcalá)
Manuel Ocaña
(University of Alcalá)

Abstract: This workshop presents important research works on perception in robotics area. Topics of interest include, but are not limited to:

- Sensor-based mobile robot localization
- Multisensor fusion and integration
- Sensor-based robot control
- Distributed sensor networks
- Simultaneous Localization and Mapping
- Computer vision in robotics
- 3D reconstruction
- Cooperative perception in robotics
- New sensing devices
- Human-Robot interaction

Web site: http://www.robesafe.es/iv2012ws_perception

Workshop on Ambient intelligence for Tomorrow's Intelligent Transportation Systems

Sunday 15:00 Room 4

Organizers: Matthew Fullerton
(Technische Universität München)
Cristina Beltrán
(Sociedad Ibérica de Construcciones Eléctricas – SICE)

Abstract: Tomorrow's ITS will employ ever-more advanced control algorithms, sensor setups and vehicular inter-networking across diverse network media and devices. In addition, the role of the vehicle will change drastically from being a receiver (e.g. geographic radio data over RDS-TMC) or passive provider (e.g. floating car data) of information to being an active, communicating participant in the traffic system that involves not only the road operator but also other drivers. The session will examine the realization and evaluation of such systems at both the small diverse personal technologies) and large (societal change) levels. New planning and evaluation strategies are required, placing new demands on field tests, modeling and simulation tools. In the session we will explore how modeling and simulation work is rising to the challenge, and how close we really are to the critical mass of enabling technologies that will see these systems in operation.

Speakers are drawn from organizational, psychological, operations and engineering disciplines. The workshop is organized and supported by Technische Universität München and SICE as part of the EU FP7 project "Complex socio-technical system in ambient intelligence" (SOCIONICAL), which is extending complexity science modeling methods and tools for future socio-technical systems in transportation and evacuation scenarios.

Web site http://www.vt.bv.tum.de/index.php?option=com_content&task=view&id=256&Itemid=256

IEEE IV 2012

Panel Discussion

Panel Discussion

Tuesday 16:40

Autonomous Driving: Current Trends and Future Perspectives

Abstract: Autonomous driving is no longer a question of the far future. Companies and research institutions working in the field have fully demonstrated that self-driving vehicles are technically viable nowadays. What is missing then in order to have driverless cars deployed on public roads? Which are the technological trends in the field in terms of sensors, algorithms, and processing devices? Which are the future plans of car manufacturers and other main stakeholders such as policy makers, technology providers or insurance companies? These and other issues will be tackled in IV12 Panel Discussion on Autonomous Driving. For such purpose, five distinguished experts in the field will provide their views on the topic from quite different but complementary perspectives.

Moderator: Miguel Ángel Sotelo
(University of Alcalá)

Panel Discussion

Panel Members

Juhani Jääskeläinen

Head of Unit
ICT for Transport. INFSO G4
European Commission

Bio: Juhani Jääskeläinen holds currently the position of Head of Unit, ICT for Transport, at the European Commission, Directorate-General Information Society, in Brussels, Belgium. He has a M.Sc. in Electrical Engineering and Computer Science from the University of Technology, Helsinki, Finland. Mr. Jääskeläinen joined the European Commission in 1996 as a Principal Scientific Officer, working in the management of the Framework Programmes for Research and Technological Development. In 1999 he was nominated Head of Sector, Mobility Services in the Directorate - General Information Society (INFSO), and in 2005 he became Deputy Head of Unit. In July 2009 he was nominated the Head of Unit, INFSO G4, ICT for Transport. The Unit's main responsibility is planning and managing Community supported research in the area of Information and Communications Technologies (ICTs) applied to transportation, as well as managing the highly successful joint industry - public sector Intelligent Car and eSafety initiatives. As HoU, Mr. Jääskeläinen is fully responsible for the research actions of the Unit, which cover safety, energy efficiency, logistics and mobility. Mr. Jääskeläinen has a leading role in the Intelligent Car Initiative and he is currently the chair of the iMobility Forum and its Steering Group, as well as the author of four Commission Communications on eSafety and in-vehicle emergency call (eCall) between 2003 and 2007. He is also Chair of the European eCall Implementation Platform (EeIP).

Currently, Mr Jääskeläinen is co-chairing the EU-US Cooperation Task Force, he is a member of the Committee on Intelligent Transportation Systems – AHB15 of the Transport Research Board (TRB) of the U.S. Moreover is Mr Jääskeläinen involved in the cooperation between EU and the Japanese Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) as well as the Japanese Ministry of Economy, Trade and Industry (METI) in the field of ITS. Mr. Jääskeläinen has a thorough industrial experience, and he has worked in the management of Research and Development in various international companies that include Ericsson and Asea Brown Boweri. Before joining the Commission he worked for several years at the Finnish Technology Development Agency TEKES, first as a Research Manager for Space Technologies and later as the Director of Space Technologies.

Panel Discussion

Panel Members

Chris Urmson

Head of Engineering – Self Driving Car
Google Inc.
Mountain View, USA

Bio: Chris Urmson is the head of engineering for Google's self-driving car program and is an adjunct professor at Carnegie Mellon University. Chris was the Director of Technology for the team that won the 2007 DARPA Urban Challenge. He has developed several robotic navigation architectures and software systems currently in use by Carnegie Mellon University, NASA JPL and NASA Ames. He earned his PhD in 2005 from Carnegie Mellon and his B.Sc. in Computer Engineering from the University of Manitoba in 1998.

Ralf G. Herrtwich

Director Driver Assistance and Chassis Systems
Group Research and Advanced Engineering
Daimler AG

Bio: Ralf G. Herrtwich is with Daimler Group Research and Advanced Engineering since 1998. After ten years as Director for Infotainment and Telematics, he is now head of Driver Assistance and Chassis Systems, in charge of conceiving and developing future safety and comfort innovations for Mercedes-Benz. A computer scientist by education, Dr. Herrtwich started his career in academia at the TU Berlin and UC Berkeley. He then held management positions with IBM and several telecommunication start-ups before joining Daimler. Since 2009, he also is honorary professor for vehicle information technology at TU Berlin.

Panel Discussion

Panel Members

Christoph Stiller

Chaired Professor and Director
Karlsruhe Institute of Technology
Karlsruhe, Germany
President of the IEEE Intelligent Transportation Systems Society

Bio: Christoph Stiller studied Electrical Engineering in Aachen, Germany and Trondheim, Norway, and received the Diploma degree and the Dr.-Ing. degree (Ph.D.) from Aachen University of Technology in 1988 and 1994, respectively. He worked with INRS-Telecommunications in Montreal, Canada for a post-doctoral year as Member of the Scientific Staff in 1994/1995. In 1995 he joined the Corporate Research and Advanced Development of Robert Bosch GmbH, Germany. In 2001 he became chaired professor and director of the Institute for Measurement and Control Systems at Karlsruhe Institute of Technology, Germany. Dr. Stiller has been elected President of the IEEE Intelligent Transportation Systems Society (2012-2013). He serves as Associate Editor for the IEEE Transactions on Intelligent Transportation Systems (2004-ongoing), IEEE Transactions on Image Processing (1999-2003) and as Editor-in-Chief of the IEEE Intelligent Transportation Systems Magazine (2009-2011). He has served as program chair for the IEEE Intelligent Vehicles Symposium 2004 in Italy and as General Chair of the IEEE Intelligent Vehicles Symposium 2011 in Germany. His autonomous driving team AnnieWAY has been finalist in the Darpa Urban Challenge 2007 and winner of the Grand Cooperative Driving Challenge in 2011.

Alberto Broggi

Full Professor. Universita` di Parma
CEO. Vislab
Parma, Italy

Past-President of the IEEE Intelligent Transportation Systems Society

Bio: Prof. Alberto Broggi received the Dr. Ing. (Master) degree in Electronic Engineering and the Ph.D. degree in Information Technology both from the Universita` di Parma, Italy, in 1990 and 1994, respectively. He is now Full Professor at the Universita` di Parma. He is the Director of the Artificial Vision and Intelligent Systems Lab of Parma University and CEO of the VisLab spinoff company, and author of more than 150 scientific publications. He served as Editor-in-Chief of the IEEE Transactions on Intelligent Transportation Systems for the term 2004-2008; he served the IEEE Intelligent Transportation Systems Society as President for the term 2010-2011, and now he is holding the Past-President position.

IEEE IV 2012

General Information

Welcome Reception and Banquet

Paraninfo Room and Hotel el Parador

Monday 19:30 – Welcome Reception

The Welcome Reception will take place at the historic Paraninfo Room at UAH's Rectorate

Tuesday 21:00 – Banquet

The Banquet will take place at the Hotel el Parador

Note: A map can be found at the end of this program book

Paraninfo Room and Patio Trilingüe

The Paraninfo or Theatre Room was constructed under the guidance of Pedro de la Cotera; its building works started in 1516, plainly integrated in the Cisnerian approach that drove the design of the whole University of Alcalá, and overlooking the beautiful Patio Trilingüe at the University of Alcalá. A great number of remarkable, official acts were celebrated in this room during the 16th and 17th centuries, becoming since then a relevant site in the national political and cultural life. The ceremony of the prestigious Cervantes's Award takes place every year in this theatre chaired by his Majesty the King of Spain.

Hotel El Parador

Parador de Alcalá de Henares is housed in a magnificent seventeenth-century building, the former Santo Tomás Dominican Convent and School. It is one of the city's landmarks along with Hostería del Estudiante, in the former Minor School of San Jerónimo, founded by Cardinal Cisneros in 1510. These monuments form a complex that was designated by UNESCO as a World Heritage site. Around the cloisters at the Santo Tomás School-Convent there are the restaurant, the bar, the breakfast room, the guests' lounge, and the night bar. Hotel el Parador serves a wide range of courses, including Cervantine food and the well-known traditional "costradas".

Demonstrations

INTA testing ground – June 7th

The symposium offers the opportunity to present test vehicles. The vehicle demonstration will take place on June, 7th at a testing ground in INTA (National Institute for Aerospace Technology) nearby Alcalá de Henares. The exhibitioners can show prototype vehicles in pavilions, and they may use the test track to show the functionality of their vehicles to the participants, and the accredited press/radio/TV.

Timetable June 7th, 2012

09:00 – 10:00:	Demonstration to the accredited press/radio/TV
10:00 – 14:00:	Demonstration to the conference participants

A bus shuttle service between Alcalá de Henares, the testing ground, and the airport will be provided. The departure times are as follows.

From Alcalá de Henares to testing ground

Hotels: Parador, Cisneros	9:00
Hotels: AC, Rafael	9:00

From testing ground to the Airport

13:30, 14:00

Traveling time is approximately 20 minutes.

Local Information

Alcalá de Henares

History

The values of each place can be determined by its history, cultural heritage, heritage legacy and its people. In this sense, Alcala de Henares is and has been a city that history has given special importance. The city has important archaeological remains testify to the presence of different peoples and cultures in the area. Its foundation goes back to the Celtiberian city of Ikesancom Kombouto on which Complutum rose after the Roman conquest, hence the adjective Complutense receiving its inhabitants. With the Muslim invasion ancient city was gradually depopulated to become a fortress known as "Qal Al Wadi-l-hiyara" from which the present name of Alcala de Henares. After the reconquest of the city in 1118, the medieval began to organize around the ancient temple of San Yuste, where tradition said to have been martyred two young Christians, called Justus and Pastor, in the early fourth century. King Alfonso VII of Castile in 1129 donated land Alcala and the archbishops of Toledo, who built a great castle after castle, where kings and nobles lived, were born an emperor and queen, and took place from courts and councils to first interview between Christopher Columbus and the Catholic Monarchs.

In 1499, Cardinal Cisneros founded the Universidad Complutense, soon becoming one of the leading centers for the spreading of European Renaissance culture. Adding to this the construction boom driven by the Counter, developed a unique model city dedicated to culture, which served as an example of Spanish urbanism of modern times and has remained unchanged over time. This university character, which made the Complutense one of the most important centers for the development of Spanish, was accompanied by a circumstance which always gave Alcalá category of being the place where Spanish language acquired adult consideration: the birth of Miguel de Cervantes in 1547. Currently, the Historical Center of the city, declared World Heritage by UNESCO in 1998, is one of the most beautiful and best preserved in Europe. Alcala also belongs to the Group of World Heritage Cities of Spain.

We invite you to meet and feast our City of Arts and Letters, an example of hospitality and rich culture that no one should miss.

Historical Sights of Alcalá de Henares and its Surrounding

- Magistral Cathedral: Built on the place where children Justo and Pastor were buried martyrs.
- College of San Ildefonso: constituted as a center of the university structure designed by Cardinal Cisneros in 1499.
- Archbishop’s Palace: It was the residence of the archbishops of Toledo in Alcala de Henares.
- Complutum Roman City: the old forum monumental Roman city of Complutum just 15 minutes from the city center.

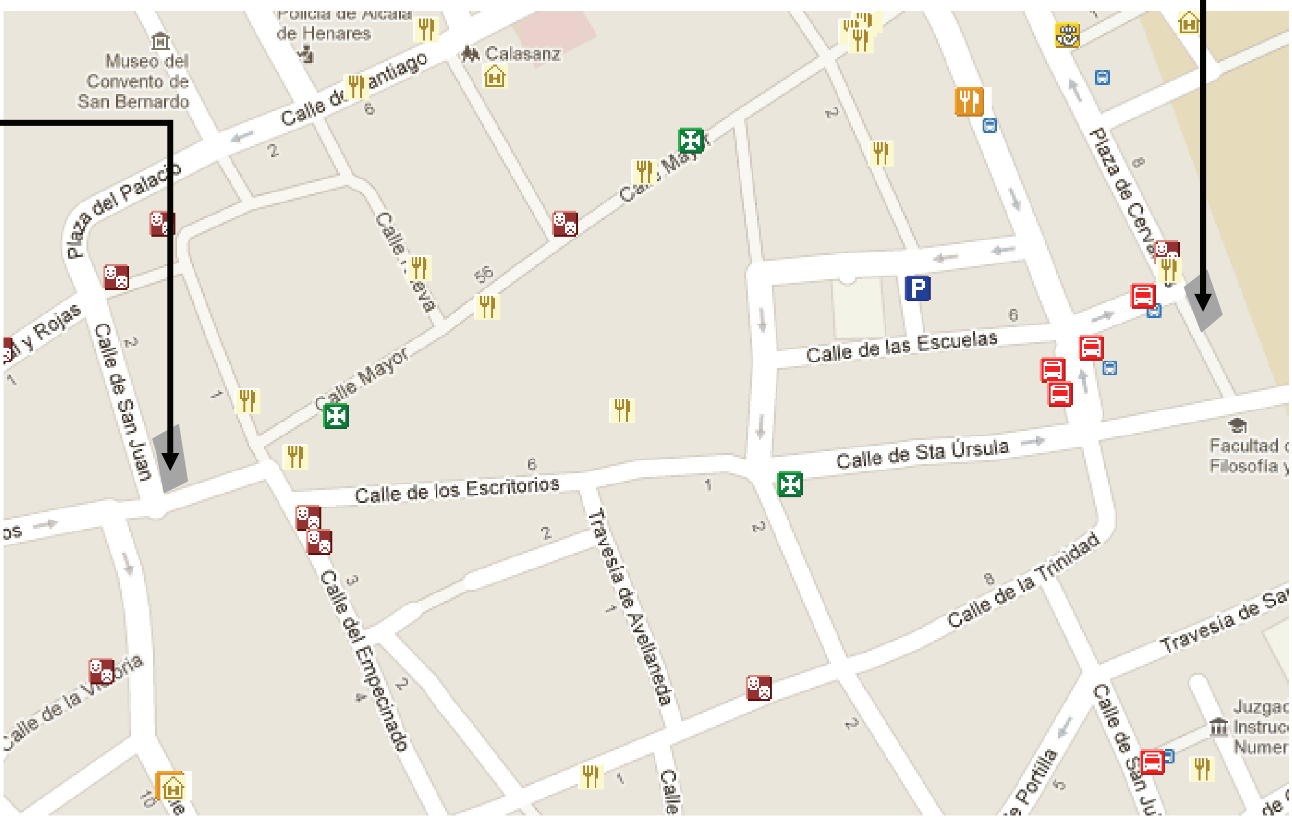
Local Information

Alcalá de Henares

Tourist Information Offices – Alcalá de Henares

Tourist Office – Plaza de Cervantes
Monday to Sunday: 10:00 – 20:00
Callejón de Santa María, s/n
Phone: +34 91 889 26 94
e-mail: otcervantes@ayto-alcaladehenares.es

Tourist Office – Plaza de los Santos Niños
Monday to Sunday: 10:00 – 20:00
Plaza de los Santos Niños, s/n
Phone: +34 91 881 06 34
e-mail: otssnn@ayto-alcaladehenares.es



Web site: http://www.turismoalcala.es

IEEE IV 2012

Abstracts

MoPO1S	Room T1
Poster Session I (Poster Session)	

Chair: Sánchez Prieto, Sebastián — Univ. de Alcalá

09:50-11:20 MoPO1S.1

Track-To-Track Fusion with Asynchronous Sensors and Out-Of-Sequence Tracks Using Information Matrix Fusion for Advanced Driver Assistance Systems, pp. 1-6

Aeberhard, Michael — BMW Group Res. and Tech.
Rauch, Andreas — BMW Group
Rabiega, Marcin — BMW Group Res. and Tech.
Kaempchen, Nico — BMW Group Res. and Tech.
Bertram, Torsten — Tech. Univ. Dortmund

Future advanced driver assistance systems will contain multiple sensors that are used for several applications, such as highly automated driving on freeways. The problem is that the sensors are usually asynchronous and their data possibly out-of-sequence, making fusion of the sensor data non-trivial. This paper presents a novel approach to track-to-track fusion for automotive applications with asynchronous and out-of-sequence sensors using information matrix fusion. This approach solves the problem of correlation between sensor data due to the common process noise and common track history, which eliminates the need to replace the global track estimate with the fused local estimate at each fusion cycle. The information matrix fusion approach is evaluated in simulation and its performance demonstrated using real sensor data on a test vehicle designed for highly automated driving on freeways.

09:50-11:20 MoPO1S.2

Pedestrian Candidates Generation Using Monocular Cues, pp. 7-12

Cheda, Diego — Univ. Autònoma de Barcelona
Ponsa, Daniel — Centre de Visió per Computador
López, Antonio M. — Univ. Autònoma de Barcelona

Common techniques for pedestrian candidates generation (e.g., sliding window approaches) are based on an exhaustive search over the image.

This implies that the number of windows produced is huge, which translates into a significant time consumption in the classification stage.

In this paper, we propose a method that significantly reduces the number of windows to be considered by a classifier.

Our method is a monocular one that exploits geometric and depth information available on single images.

Both representations of the world are fused together to generate pedestrian candidates based on an underlying model which is focused only on objects standing vertically on the ground plane and having certain height, according with their depths on the scene.

We evaluate our algorithm on a challenging dataset and demonstrate its application for pedestrian detection, where a considerable reduction in the number of candidate windows is reached.

09:50-11:20 MoPO1S.3

Novel Decentralised Formation Control for Unmanned Vehicles, pp. 13-18

Yang, Aolei — Queen's Univ. Belfast
Naeem, Wasif — Queen's Univ. Belfast
Irwin, George — Queen's Univ. Belfast
Li, Kang — Queen's Univ. Belfast

This paper proposes a new methodology for solving the unmanned multi-vehicle formation control problem. It employs a unique "extension-decomposition-aggregation" scheme to transform the overall complex formation control problem to a group of sub-problems which work via boundary interactions. The H_inf robust control strategy is applied to design the decentralised formation controllers to reject the interactions and work jointly to maintain the stability of the overall formation. Simulation studies have been performed to verify its performance and effectiveness.

09:50-11:20 MoPO1S.4

Manual Convoying of Automated Urban Vehicles Relying on Monocular Vision, pp. 19-24

Avanzini, Pierre — Inst. Pascal, Univ. Blaise Pascal
Thuilot, Benoit — LASMEA/GRAVIR/ROSACE
Martinet, Philippe — Blaise Pascal Univ.

This paper deals with platooning navigation in the context of innovative solutions for urban transportation systems. More precisely, the case of a manually driven vehicle leading a convoy of automated ones is considered. Vehicle localization relies solely on monocular vision: a 3D map of the environment is built beforehand from reference video sequences, and then used to derive vehicle absolute location from the current camera image. The 3D vision map presents however distortions w.r.t. a metric world, but these latter can be shown to be locally homogeneous. They can then be accurately corrected via a 1-dim. function evaluated with a nonlinear observer relying on odometric data. Next, the platoon reference trajectory is built as a B-Spline curve extended on-line via local optimization from the successive locations of the lead vehicle, and a global decentralized control strategy, supported by inter-vehicle communication, is designed to achieve accurate platooning with no oscillation within the convoy. Experimental results, carried out with two urban vehicles, demonstrate the capabilities of the proposed approach.

09:50-11:20 MoPO1S.5

A Practical System for Road Marking Detection and Recognition, pp. 25-30

Wu, Tao — Univ. of Maryland
Ranganathan, Ananth — Honda Res. Inst. USA

We present a system for detecting and recognizing road markings from video input obtained from an in-car camera. Our system learns feature-based templates of road markings from training data and matches these templates to detected features in the test images during runtime.We use MSER features and perform the template matching in an efficient manner so that our system can detect multiple road markings in a single image. Our system also scales well with the number of categories of road markings to be detected. For evaluating our system, we present an extensive dataset (available from www.ananth.in/RoadMarkingDataset.tar.gz) of road markings with ground truth labels, which we hope will be useful as a benchmark dataset for future researchers in this area.

09:50-11:20 MoPO1S.6

Lane-Based Safety Assessment of Road Scenes Using Inevitable Collision States, pp. 31-36

Althoff, Daniel — Tech. Univ. München
Werling, Moritz — BMW Group Forschung und Tech. GmbH
Kaempchen, Nico — BMW Group Res. and Tech.
Wollherr, Dirk — Tech. Univ. München
Buss, Martin — TU Muenchen

This paper presents a method for reasoning about the safety of traffic situations. More precisely, the problem of safety assessment for partial trajectories for vehicles is addressed. Therefore, the Inevitable Collision States (ICS) as well as its probabilistic generalization the Probabilistic Collision States (PCS) are used. Thereby, the assessment is performed for an infinite time horizon. For solving the ICS computation nonlinear programming is applied. In addition to the safety assessment an evaluation of the disturbance of the other traffic participants by the ego vehicle is presented. The results are integrated into an optimal control based planning approach that generates minimum jerk trajectories. An example implementation of the proposed framework is applied to simulation scenarios that demonstrates the necessity of the presented method for guaranteeing motion safety.

09:50-11:20 MoPO1S.7

Robust Road Boundary Estimation for Intelligent Vehicles in Challenging Scenarios Based on a Semantic Graph, pp. 37-44

Guo, Chunzhao — Toyota Tech. Inst.
Yamabe, Takayuki — Toyota Tech. Inst.
Mita, Seiichi — Toyota Tech. Inst.

This paper presents a stereovision-based detection and tracking approach of the drivable road boundary, designed for navigating an intelligent vehicle through challenging traffic scenarios, and increment road safety in such scenarios with advanced driver assistance systems (ADAS). It is based on a formulation of stereo with homography associated with a semantic graph constructed from the traffic scene. Under this formulation, we employ the Viterbi algorithm and propose a sophisticated measure of the probability of the state sequence in the semantic graph to find the most likely boundary between the road and non-road regions. The results are then refined by a post-processing step with the RANdom Sample Consensus (RANSAC) algorithm to obtain the locations and curvatures of the lateral road boundaries. Experimental results on a wide variety of typical but challenging real road scenes have substantiated the effectiveness as well as robustness of the proposed approach.

09:50-11:20 MoPO1S.8

The Effect of Vehicle Acceleration Near Traffic Congestion Fronts, pp. 45-50

Vergeest, Joris — Delft Univ. of Tech.
Arem, Bart van — Twente Univ.

Too slow acceleration of cars downstream a traffic jam can have a dramatic impact on the jam's lifetime and cause much delay for motorists behind. It has been observed that cars leaving a traffic jam reach cruise speed much later than predicted by car-following models and car drivers tend to produce a long distance to the car ahead. Using traffic flow simulation we have quantified the delays caused by such driving behavior. We also review some speculations that explain the driving style and possible remedies through vehicle intelligence.

09:50-11:20 MoPO1S.9

Generic Camera Calibration and Modeling Using Spline Surfaces, pp. 51-56

Rosebrock, Dennis — Tech. Univ. Braunschweig
Wahl, Friedrich M. — Tech. Univ. Braunschweig

Cameras are a commonly used sensor in advanced driver assistance systems (ADAS). They serve to get vast amounts of information about a vehicle's environment. To accurately localize the measured data in relation to the own car, exact camera calibration is a prerequisite. This includes extrinsic as well as intrinsic parameters. While many works in the area of ADAS focus on extrinsic calibration, this work covers the intrinsic calibration. We use a generic camera model which regards the viewing ray of every pixel separately and can therefore be used to describe arbitrary imaging devices even with massive lens distortions. As the calibration procedure works for any camera, only one method has to be implemented, which simplifies the sensor calibration process. Former works have shown the applicability of generic camera models but do not cover important practical aspects which are subpixel ray determination and forward projection of arbitrary 3d points to the image plane. Furthermore, the calibration processes described so far are cumbersome and prone to inaccuracies. We propose to use spline surfaces to simplify the calibration procedure and implement general back and forward projection. The applicability of our approach is proved by showing calibration results for various real cameras.

09:50-11:20 MoPO1S.10

Omni-Directional Detection and Tracking of On-Road Vehicles Using Multiple Horizontal Laser Scanners, pp. 57-62

Zhao, Huijing — Peking Univ.
Wang, Chao — Peking Univ.
Yao, Wen — Peking Univ.
Davoine, Franck — CNRS LIAMA Sino French Lab.
Cui, Jinshi — Peking Univ.
Zha, Hongbin — Peking Univ.

This research aims at generating an omnidirectional perception at the host vehicle's surroundings, extracting accurate and continuous motion trajectories of the nearby vehicles using low cost laser scanners. A system of detecting and tracking on-road vehicles using multiple laser scanners is developed, where focuses are cast on solving data association of simultaneous measurements from multiple sensors at different viewpoints, and state estimation in case of partial observations in dense dynamic situations. Experimental results in freeways in Beijing are presented, system efficiency is demonstrated, where motion trajectories describing driving behaviors such as overtaking, lane changing and other interactions between driving objects are captured. In addition, the accuracy in vehicle detection and tracking is examined using a reference vehicle with a ground truth GPS.

09:50-11:20 MoPO1S.11

Using Statistical Models to Characterize Eco-Driving Style with an Aggregated Indicator, pp. 63-68

Andrieu, Cindie — IFSTTAR
Saint Pierre, Guillaume — INRETS/LCPC

This paper presents the construction of an aggregated indicator of a fuel-efficient driving style, in order to construct an efficient Ecological Driving Assistance System (EDAS). Such an eco-index can be used to detect eco-driving behaviour, but also to give the driver useful advices to help him improving his driving efficiency without deteriorating safety. The logistic regression is used to modelize our experimental dataset of twenty subjects driving twice the same track: normally or following the golden rules of eco-driving. Depending on some driving indicators, the estimated probability of being an eco-driver is used as an eco-index to characterize that driving pattern. This work show how such a simple aggregated indicator, related to driving dynamics rather than fuel consumption, can be useful for driver monitoring and information. Two models, from the simplest to the most complicated, are compared, and their performances analysed.

09:50-11:20 MoPO1S.12

Visual Odometry Based on Random Finite Set Statistics in Urban Environment, pp. 69-74

Zhang, Feihu — Tech. Univ. München
Chen, Guang — Tech. Univ. of Munich
Staehle, Hauke — Tech. Univ. Muenchen
Buckl, Christian — fortiss GmbH
Knoll, Alois — Tech. Univ. München

This paper presents a novel approach for estimating the vehicle's trajectory in complex urban environments. In previous work, we presented a visual odometry solution that estimates frame-to-frame motion from a single camera based on Random Finite Set (RFS) Statistics. This paper extends that work by combining the stereo cameras and gyroscope sensor. We are among the first to apply RFS statistics to visual odometry in real traffic scenes. The method is based on two phases: a preprocessing phase to extract features from image coordinates to vehicle coordinates and a tracking phase to estimate the ego-motion vector of the camera. We consider features as a group target and use the Probability Hypothesis Density (PHD) filter to update the overall group state as the motion vector. Compared to other approaches, our method presents a recursive filtering algorithm that provides dynamic estimation of multiple-targets states in the presence of clutter and high association uncertainty.

The experimental results show that this method exhibits good robustness under various scenarios.

09:50-11:20 MoPO1S.13

Optimal Motion Planning Based on CACM-RL Using SLAM, pp. 75-80

Arribas Navarro, Tomás — Univ. de Alcalá
Gómez Plaza, Mariano — Univ. de Alcalá
Sánchez Prieto, Sebastián — Univ. de Alcalá

This work aims to integrate SLAM into the path planning based on Control Adjoining Cell Mapping and Reinforcement Learning (CACM-RL) algorithm to give a total autonomy and auto-location to mobile vehicles. This way, the implementation does not depend on any external device (e.g. camera) to perform optimal control and motion planning. SLAM is performed using Particle Filtering based on the information provided by inexpensive ultrasonic sensors and odometry. A real scenario, in where some obstacles have been introduced, is used to demonstrate the efficiency and viability of the proposed technique.

09:50-11:20 MoPO1S.14

Adaptive Control Solutions for the Position Control of Electromagnetic Actuated Clutch Systems, pp. 81-86

Dragos, Claudia-Adina — Pol. Univ. of Timisoara
Preitl, Stefan — Pol. Univ. of Timisoara
Precup, Radu-Emil — Pol. Univ. of Timisoara
Petriu, Emil M. — Univ. of Ottawa
Stinean, Alexandra-Iulia — Pol. Univ. of Timisoara

The paper proposes low-cost adaptive control solutions dedicated to the position control of electromagnetic actuated clutch systems. The initial nonlinear model of the plant is simplified and next linearized to use it in the controller design procedures. A comparative analysis between five control solution (CS) – the classical PI and PID CS, the fuzzy CS, the adaptive CS with PI gain-scheduling controllers and fuzzy PID gain-scheduling CS – is carried out. The solutions were tested based on a nonlinear simplified model of the plant.

09:50-11:20 MoPO1S.15

Localization in Digital Maps for Road Course Estimation Using Grid Maps, pp. 87-92

Konrad, Marcus — EvoBus GmbH - Daimler Buses
Nuss, Dominik Stefan — Univ. of Ulm
Dietmayer, Klaus — Univ. of Ulm

Grid maps are a reliable representation of the environment. Based on a generic grid map definition, this paper presents three formulations: a laser scanner based occupancy grid, a video grid based on the Inverse Perspective Mapping and a novel feature grid, where lane marking features are used. Furthermore, this contribution presents a road course estimation based on such grid maps which yields estimations above 120m. Therefore, a digital road map (comparable to maps of GPS navigation systems) is matched to a grid map. Thus, a global position in the road map is estimated. Finally, a novel evaluation approach is presented to quantize the results of this grid map based map match.

09:50-11:20 MoPO1S.16

Risk Indicators Anticipation Based on the Vehicle Dynamics Anticipation to Avoid Accidents, pp. 93-98

Ghandour, Raymond — Univ. de Tech. de Compiègne
Victorino, Alessandro — Univ. de Tech. de Compiegne, Departement deGenie Info
Charara, Ali — HEUDIASYC UMR UTC/CNRS 6599
Lechner, Daniel — INRETS-MA

This article leads to the challenging problem of increasing vehicle driving security by applying on boarded intelligent diagnosis systems; it presents a methodology of evaluating, in an anticipated way, the risk of having an accident (skid and rollover). The methodology consists in adopting assumptions about the trajectory, the longitudinal velocity and the longitudinal acceleration in future instants and use these assumptions, allied to previous road information to calculate the future vehicle dynamics parameters. Once calculated, the risk indicators based on these parameters could be predicted in order to expect and avoid possible dangerous situations. These indicators are the lateral load transfer (LTR) based on vertical forces, and the lateral skid indicator (LSI) based ont the maximum friction coefficient and the used friction coefficient. A sliding window system is used to apply the method on the whole trajectory to take into account the vehicle dynamics updates by the driver.

09:50-11:20 MoPO1S.17

Local Stereo Disparity Estimation with Novel Cost Aggregation for Sub-Pixel Accuracy Improvement in Automotive Applications, pp. 99-104

Zhang, Zhen — Univ. of Bristol
Ai, Xiao — Univ. of Bristol
Canagarajah, Nishan — Univ. of Bristol
Dahnoun, Naim — Univ. of Bristol

This paper presents a local disparity calculation algorithm on calibrated stereo images based on cost aggregation. Unlike most of the existing cost aggregation methods which are mainly based on the grouping of colour similarities, the proposed algorithm is grouped by local cost similarities. The proposed algorithm also applies a bilateral filter to enhance the normalised cost volume and, then, uses the winner-take-all technique to select the correspondence candidates. Finally, a quadratic polynomial interpolation is performed using the candidates and their neighbourhood values to achieve sub-pixel disparity resolution. The experimental results indicate that the proposed algorithm is able to provide dense disparity maps with sub-pixel resolution and achieves better accuracy compared to two similar stereo matching algorithms.

09:50-11:20 MoPO1S.18

Scene Understanding from a Moving Camera for Object Detection and Free Space Estimation, pp. 105-110

Haltakov, Vladimir — BMW AG
Belzner, Heidrun — BMW Group
Ilic, Slobodan — Tech. Univ. München

Modern vehicles are equipped with multiple cameras which are already used in various practical applications. Advanced driver assistance systems (ADAS) are of particular interest because of the safety and comfort features they offer to the driver. Camera based scene understanding is an important scientific problem that has to be addressed in order to provide the information needed for camera based driver assistance systems. While frontal cameras are widely used, there are applications where cameras observing lateral space can deliver better results. Fish eye cameras mounted in the side mirrors are particularly interesting, because they can observe a big area on the side of the vehicle and can be used for several applications for which the traditional front facing cameras are not suitable. We present a general method for scene understanding using 3D reconstruction of the environment around the vehicle. It is based on pixel-wise image labeling using a conditional random field (CRF). Our method is able to create a simple 3D model of the scene and also to provide semantic labels of the different objects and areas in the image, like for example cars, sidewalks, and buildings. We demonstrate how our method can be used for two applications that are of high importance for various driver assistance systems - car detection and free space estimation. We show that our system is able to perform in real time for speeds of up to 63 km/h.

09:50-11:20 MoPO1S.19

A Feasability Study of Drowsiness Detection Using Driving Behaviour Parameters, pp. 111-116

Bartra Cisa, Ariadna — Ficosa
Meca, Pablo — IBEC
Pardo, Antoni — Univ. of Barcelona
Marco, Santiago — Inst. for BioEngineering of Catalonia
Montesi, Alan — Ficosa
Guamán, Ana — Inst. for BioEngineering of Catalonia

One of the main causes of car accidents is drowsiness. There have been many studies regarding driving monitoring systems in the past few years, although most of them are focused in simulator environments. This paper presents a system to detect drowsiness patterns in real driving environments, where many external conditions need to be taken into account. Initial tests were done in simulator, followed by tests in real vehicles. Although two different approaches have been developed, this paper is focused in the inadequate driving identification based on the steering movements. Its sub-modules are also presented, with a special focus on the active driving detector.

09:50-11:20 MoPO1S.20

Contrast Invariant Features for Human Detection in Far Infrared Images, pp. 117-122

Olmeda, Daniel — Univ. Carlos III
de la Escalera, Arturo — Univ. Carlos III de Madrid
Armingol Moreno, José María — Univ. Carlos III de Madrid

In this paper a new contrast invariant descriptor for human detection

in long-wave infrared images is proposed. It exploits local information histogram of orientations of phase coherence. Contrast in infrared images depends on the temperature of the object and the background, which makes gradient based descriptors less robust, especially in daylight conditions. The objective is to obtain a scale, brightness and contrast invariant descriptor that can successfully detect pedestrians in images taken with a cheap, temperature-sensitive, uncooled microbolometer. The descriptor, packed into grids is feed to a Support Vector Machine classifier. The algorithm has been tested in night and day sequences and its performance is compared with a day only descriptor: the histogram of oriented features (HOG).

09:50-11:20 MoPO1S.21

Detection of Missing Roundabouts in Maps for Driving Assistance Systems, pp. 123-128

Zinoune, Clément — Univ. of Tech. of Compiègne, Renault SAS
Bonnifait, Philippe — Univ. of Tech. of Compiegne
Ibanez Guzman, Javier — Renault S.A.S,

Passenger vehicles are evolving into sensorbased computer controlled platforms with different levels of autonomy. Digital maps representing road networks are being used as an a priori source of information to provide context and to anticipate oncoming situation. On top of it, world models are built for machine understanding. However, these can have local errors, affecting location based functions. A common one is due to the rapid deployment of roundabouts, as they are introduced widely, with navigation maps ignoring their presence. This work introduces a novel approach to make the vehicle able to detect the presence of a roundabout while it is driven. It is then possible to update the map by the vehicle itself. The approach is based on graphical pattern recognition methods using a Bayesian classifier. The approach has been demonstrated experimentally using data acquired in real-traffic conditions.

09:50-11:20 MoPO1S.22

Path and Speed Control of a Heavy Vehicle for Collision Avoidance Manoeuvres, pp. 129-134

Hassanzadeh, Morteza — Chalmers Univ. of Tech.
Lidberg, Mathias — Chalmers Univ. of Tech.
Keshavarz Bahaghighat, Mansour — Volvo AB, Group Trucks Tech.
Bjelkeflo, Lars — Volvo Tech.

In an emergency situation prior to an imminent accident, first in-vehicle warning systems would intervene and aim to make the driver to take a suitable action. If the risk of accident was not eliminated, then an autonomous collision avoidance manoeuvre can prevent it. In this work, path and speed control are intended to be used to perform such a manoeuvre by using steering and braking actuators respectively. In order to provide actuators with suitable control inputs, first a path is planned for the heavy vehicle to follow during the manoeuvre. Then the path is used to calculate feedforward control inputs whereas a feedback controller assures the path tracking by compensating for errors. As a result, a robust path planning and control algorithm is designed and implemented that can perform autonomous collision avoidance manoeuvres for a heavy vehicle. Promising simulation results support ongoing works on vehicle demonstration and experiments on a real heavy vehicle.

09:50-11:20 MoPO1S.23

A Centralized Traffic Controller for Intelligent Vehicles in a Segment of a Multilane Highway, pp. 135-140

Reghelin, Ricardo — Univ. Tecnológica Federal do Paraná
Arruda, Lúcia Valéria Ramos — Univ. Tecnológica Federal do Paraná (UTFPR)

This paper presents two contributions in the study of Automated Highway System. The first one is a solution to calculate the coordinated movement of intelligent vehicles in a multilane highway for a fixed period of time. An optimization model that considers travel time as criteria and considers topography of the lane, traffic rules and curve of acceleration of each vehicle is presented. The model deals with many traffic situations such as overtaking and reduction in lanes. As the model takes time to run, an algorithm based on traffic simulators is proposed. The other contribution is a solution for the overtaking priority problem and it is based on references provided by the algorithm results. Moreover, new concepts for microscopic traffic assessment are proposed. Simulation tests are presented to evaluate the model and the algorithm.

09:50-11:20 MoPO1S.24

Probabilistic Trajectory Prediction with Gaussian Mixture Models, pp. 141-146

Wiest, Jürgen — Univ. of Ulm
Höffken, Matthias — Univ. of Ulm
Kressel, Ulrich — Daimler AG
Dietmayer, Klaus — Univ. of Ulm

In the context of driver assistance, an accurate and reliable prediction of the vehicle's trajectory is beneficial. This can be useful either to increase the flexibility of comfort systems or, in the more interesting case, to detect potentially dangerous situations as early as possible. In this contribution, a novel approach for trajectory prediction is proposed which has the capability to predict the vehicle's trajectory several seconds in advance, the so called long-term prediction. To achieve this, previously observed motion patterns are used to infer a joint probability distribution as motion model. Using this distribution, a trajectory can be predicted by calculating the probability for the future motion, conditioned on the current observed history motion pattern. The advantage of the probabilistic modeling is that the result is not only a prediction, but rather a whole distribution over the future trajectories and a specific prediction can be made by the evaluation of the statistical properties, e.g. the mean of this conditioned distribution. Additionally, an evaluation of the variance can be used to examine the reliability of the prediction.

09:50-11:20 MoPO1S.25

A Probabilistic Discriminative Approach for Situation Recognition in Traffic Scenarios, pp. 147-152

Tran, Quan — KIT
Firl, Jonas — Adam Opel AG

Understanding of traffic situations is an essential part of future advanced driver assistance systems (ADAS). This has to handle spatio-temporal dependencies of multiple traffic participants and uncertainties from different sources. Most existing approaches use probabilistic generative joint structures like Hidden Markov Models (HMM), which have long been used for dealing with activity recognition problems. Two significant limitations of these models are the assumption of conditional independence of observations and the availability of prior information. In this study, we present a probabilistic discriminative approach based on undirected probabilistic graphical models (Markov Networks). We combine two well-studied models: the log-linear model and the Conditional Random Field (CRF), which use dynamic programming for efficient, exact inference and their parameters can be learned via convex optimization. Since CRF conditions on entire observation sequences, we can avoid the requirement of independence between observations. Additionally, with discriminative models prior information of each activity is not necessary when performing a classification step. These two advantages of the discriminative models are very useful for our focusing problem of traffic scene understanding. We evaluate our approach with real data and show that it is able to recognize different driving maneuvers occurring at an urban intersection.

09:50-11:20 MoPO1S.26

Supervised Landmask Estimation Using Contextual Information in SAR Data, pp. 153-158

Martin de Nicolas, Jaime — Univ. of Alcala
Barcena-Humanes, Jose-Luis — Univ. of Alcala
Palma-Vazquez, Angel — Univ. of Alcala
Mata-Moya, David — Univ. of Alcalá
Jarabo-Amores, Maria-Pilar — Univ. of Alcala

Synthetic Aperture Radars are powerful observation tools in cases where the utilization of optical data is restricted. As one of the main applications of these systems is the control of maritime traffic, a land mask needs to be estimated. In this paper two different processing schemes are proposed in order to perform the land mask estimation on a TerraSAR-X acquired SAR image. The first one consists on an unsupervised edge detector based on the wavelet transform modulus maxima, while the second one performs a supervised detection based on SVMs. Both processing schemes apply a blocktracing algorithm after the edge detection stage. The edge detector based on the wavelet transform finds quite a lot of edges over the sea area, missclassifying a big region of water as land. Thanks to contextual information and the supervised training, the edge detector based on SVMs can outperform the classification of sea areas obtaining a better landmask.

09:50-11:20 MoPO1S.27

Frontal Object Perception Using Radar and Mono-Vision, pp. 159-164

Chavez-Garcia, R. Omar	Univ. Joseph Fourier
Burlet, Julien	TRW Conekt
Vu, Trung-Dung	AMA/LIG Univ. Grenoble 1
Aycard, Olivier	Univ. Grenoble1

In this paper, we detail a complete software architecture of a key task that an intelligent vehicle has to deal with: frontal object perception. This task is solved by processing raw data of a radar and a mono-camera to detect and track moving objects. Data sets obtained from highways, country roads and urban areas were used to test the proposed method. Several experiments were conducted to show that the proposed method obtains a better environment representation, i.e., reduces the false alarms and missed detections from individual sensor evidence.

MoOR1S Room T1

Driver Assistance Systems I (Regular Session)

Chair: Barth, Matthew — Univ. of California-Riverside

11:20-11:40 MoOR1S.1

Risk Assessment at Road Intersections: Comparing Intention and Expectation, pp. 165-171

Lefevre, Stephanie	INRIA
Laugier, Christian	INRIA
Ibanez Guzman, Javier	Renault S.A.S,

Intersections are the most complex and hazardous areas of the road network, and 89% of accidents at intersection are caused by driver error. We focus on these accidents and propose a novel approach to risk assessment: in this work dangerous situations are identified by detecting conflicts between intention and expectation, i.e. between what drivers intend to do and what is expected of them. Our approach is formulated as a Bayesian inference problem where intention and expectation are estimated jointly for the vehicles converging to the same intersection. This work exploits the sharing of information between vehicles using V2V wireless communication links. The proposed solution was validated by field experiments using passenger vehicles. Results show the importance of taking into account interactions between vehicles when modeling intersection situations.

11:40-12:00 MoOR1S.2

Electric Vehicle Travel Optimization — Customer Satisfaction Despite Resource Constraints, pp. 172-177

Hoch, Nicklas	ETH Zurich, Volkswagen AG
Zemmer, Kevin	ETH Zurich
Werther, Bernd	Volkswagen AG
Siegwart, Roland	ETH Zurich

Consumers and producers of mobility products have been co-creating a mobile world – all within the limits of political regulation and infrastructure realities. With the advent of electric vehicles, the existing mobile world requires adaptation: Producers need to create new ecosystems and mobility concepts, infrastructure requires adaptation and lastly consumers might revisit their expectations.

Particularly challenging is the market introduction phase of electric vehicles. Neither have the potentials of the infrastructure and the electric vehicles been fully exploited, nor have consumers become accustomed to electric vehicles and shaped their expectations accordingly. Making electric vehicles a success story requires the satisfaction of customer expectations in the face of both electric vehicle and infrastructure realities.

This paper suggests an optimization approach which maximizes customer satisfaction for existing electric vehicle and infrastructure realities. For various degrees-of-freedom (DoF) of the mobility system, the improvement potential is analysed with respect to consumption, charging time, cost and travel time. Moreover, the optimization complexity is analysed, which scales with the number of DoF. The approach enables market entry of electric vehicles and provides the means for future e-navigation and e-travel-planning.

12:00-12:20 MoOR1S.3

Detectability Prediction in Dynamic Scenes for Enhanced Environment Perception, pp. 178-183

Engel, David	Massachusetts Inst. of Tech.
Curio, Cristobal	Max Planck Inst. for Biological Cybernetics

A driver assistance system realizes that the driver is distracted and that a potentially hazardous situation is emerging. Where should it guide the attention of the driver? Optimally to the spot that allows the driver to make the best decision. Pedestrian detectability has been proposed recently as a measure of the probability that a driver perceives pedestrians in an image. Leveraging this information allows a driver assistance system to direct the attention of the driver to the spot that maximizes the probability that all pedestrians are seen.

In this paper we extend this concept to dynamic scenes. We use an annotated video dataset recorded from a moving car in an urban environment and acquire the detectabilities of pedestrians via a psychophysical experiment. Based on these measured detectabilites we train a machine learning algorithm to predict detectabilities from a set of image features. We then exploit this mapping to predict the optimal focus of attention in a second experiment, thus demonstrating the usefulness of our method in a dynamic driver assistance context.

12:20-12:40 MoOR1S.4

Multipath Detection with 3D Digital Maps for Robust Multi-Constellation GNSS/INS Vehicle Localization in Urban Areas, pp. 184-190

Obst, Marcus	Chemnitz Univ. of Tech.
Bauer, Sven	Chemnitz Univ. of Tech.
Reisdorf, Pierre	Chemnitz Univ. of Tech.
Wanielik, Gerd	Chemnitz Univ. of Tech.

Reliable knowledge of the ego position for vehicles is a crucial requirement for many automotive applications. In order to solve this problem for GNSS-based localization in dense urban areas, multipath situations need to be handled carefully. This paper proposes a lightweight multipath detection algorithm which is based on dynamically built 3D environmental maps. The algorithm is evaluated with simulated and real-world data. Furthermore, it is applied to single and multi-constellation GNSSs.

MoOR2S Room T1

Cooperative Vehicle-Highway Systems (Regular Session)

Chair: Salgado, Luis — Univ. Pol. de Madrid

13:50-14:10 MoOR2S.1

Reducing Congestion at Uphill Freeway Sections by Means of a Gradient Compensation System, pp. 191-198

Goñi Ros, Bernat	Delft Univ. of Tech.
Knoop, Victor	Delft Univ. of Tech.
van Arem, Bart	Delft Univ. of Tech.
Hoogendoorn, Serge	Delft Univ. of Tech.

Uphill sections have often been identified as capacity bottlenecks in freeway networks. One of the main reasons seems to be that drivers reduce speed when they reach the beginning of an uphill section. With high traffic demand, the deceleration of the first vehicle of a platoon can generate a flow disturbance that amplifies as it propagates upstream, triggering the formation of a traffic jam. This paper presents a proof of concept by exploring whether equipping the leader of a platoon with an in-vehicle Gradient Compensation System (GCS) can improve traffic flow efficiency on uphill sections. The GCS assists the driver in performing the longitudinal driving task at uphill sections. We present the results of a series of traffic simulation experiments in which a platoon of vehicles drive on a single-lane freeway stretch containing an uphill section. The phenomenon of speed reduction is modeled by means of a sub-microscopic traffic simulation program. The results show that if the platoon leader is not equipped with the GCS, its speed drop at the beginning of the uphill section can cause a traffic breakdown, as observed in reality. However, if the platoon leader is equipped with the GCS, the magnitude of the speed drop is reduced, preventing congestion formation.

14:10-14:30	MoOR2S.2

A Classification of Expressway Traffic Flow Characteristics Based on Different Distances between On-Ramp and Off-Ramp, pp. 199-204

Zhang, Haizheng	Tsinghua Univ.
Shengchao, Yin	Tsinghua
Yao, Danya	Tsinghua Univ.
Su, Yuelong	China National BlueStar (Group) Co., Ltd.,

this paper focuses on the influence on traffic flow characteristics of distance between on-ramp and off-ramp in expressway. In this research, those characteristics include traffic flow rate, average speed and average density. Based on VISSIM, we calibrated key parameters and a calibrating procedure is proposed. Then we simulated scenarios with different distances from 100m to 1000m. Analyses of the distance's influence on traffic flow characteristics are studied using simulation results. Finally, 3 modes are classified out of different distances and 2 thresholds are proposed. The two thresholds are within 100-200m and 500-600m and if distance varies through these, traffic flow characteristics will change significantly. Finally, as for verification, we compared 3 scenarios of simulation and reality. In the future, different control strategies may be applied due to different conditions.

14:30-14:50	MoOR2S.3

2-Way Evaluation of the Distributed BeeJamA Vehicle Routing Approach, pp. 205-210

Senge, Sebastian	TU Dortmund
Wedde, Horst F.	TU Dortmund

We present and evaluate our adaptive and distributed vehicle routing approach, termed BeeJamA, which provides drivers safely with routing directions well before each intersection. Our approach is based on a multi-agent system which is inspired by the honey bee behavior and relies on a V2I architecture. We report on our extensive simulation experiments verifying for very large systems that BeeJamA substantially outperforms all A*-based algorithms relying on global information systems, in particular under all degrees of penetration rates as well as considering reactive flexibility and easy scalability.

14:50-15:10	MoOR2S.4

Cooperative Multi-Vehicle Localization Using Split Covariance Intersection Filter, pp. 211-216

Li, Hao	Mines Paris (ParisTech) / INRIA-IMARAteam
Nashashibi, Fawzi	Mines ParisTech / INRIA

Vehicle localization (ground vehicles) is an important task for intelligent vehicle systems and vehicle cooperation may bring benefits for this task. A new cooperative multi-vehicle localization method using split covariance intersection filter is proposed in this paper. In the proposed method, each vehicle maintains an estimate of a decomposed group state and this estimate is shared with neighboring vehicles; the estimate of the decomposed group state is updated with both the sensor data of the ego-vehicle and the estimates sent from other vehicles; the covariance intersection filter which yields consistent estimates even facing unknown degree of inter-estimate correlation has been used for data fusion. A comparative study based simulations demonstrate the effectiveness and the advantage of the proposed cooperative localization method

MoPO2S	Room T1
Poster Session II (Poster Session)	
Chair: Sjöberg, Jonas	Chalmers Univ.

15:10-16:40	MoPO2S.1

An Electronic System to Combat Drifting and Traffic Noises on Saudi Roads, pp. 217-222

Ben Dhaou, Imed	Al Jouf Univ.

This paper proposes an electronic system to combat drifting and traffic noises in the urban area of Saudi Arabia. The proposed solution can be integrated into a smart city platform. The system comprises a sound processing hardware, a CCTV camera, and a GPRS module for wireless IP access. An algorithm to address drifting for noise and accidents is derived and tested over a range of audible traffic noises in Sakakah town. Hardware implementation of the algorithm using Radix-8, 64-point FFT algorithm, and a semiconductor intellectual property is elaborated. The results show that the algorithm produces no false alarm.

15:10-16:40	MoPO2S.2

HOG-Like Gradient-Based Descriptor for Visual Vehicle Detection, pp. 223-228

Arróspide, Jon	Univ. Pol. de Madrid
Salgado, Luis	Univ. Pol. de Madrid
Marinas, Javier	Univ. Pol. de Madrid

One of the main challenges for intelligent vehicles is the capability of detecting other vehicles in their environment, which constitute the main source of accidents. Specifically, many methods have been proposed in the literature for video-based vehicle detection. Most of them perform supervised classification using some appearance-related feature, in particular, symmetry has been extensively utilized. However, an in-depth analysis of the classification power of this feature is missing. As a first contribution of this paper, a thorough study of the classification performance of symmetry is presented within a Bayesian decision framework. This study reveals that the performance of symmetry-based classification is very limited. Therefore, as a second contribution, a new gradient-based descriptor is proposed for vehicle detection. This descriptor exploits the known rectangular structure of vehicle rears within a Histogram of Gradients (HOG)-based framework. Experiments show that the proposed descriptor outperforms largely symmetry as a feature for vehicle verification, achieving classification rates over 90%.

15:10-16:40	MoPO2S.3

Generating Approximative Minimum Length Paths in 3D for UAVs, pp. 229-233

Schøler, Flemming	Aalborg Univ.
la Cour-Harbo, Anders	Aalborg Univ.
Bisgaard, Morten	Aalborg Univ.
Hansen, Karl Damkjaer	Aalborg Univ.

We consider the challenge of planning a minimum length path from an initial position to a final position for a rotorcraft. The path is found in a 3-dimensional Euclidean space containing a geometric obstacle. We base our approach on visibility graphs which have been used extensively for roadmap based path planning in 2-dimensional Euclidean space. Generalizing to 3-dimensional space is not straight-forward, unless a visibility graph is generated that, when searched, will only provide an approximate minimum length path. Our approach generates such a visibility graph that is composed by an obstacle graph and two supporting graphs. The obstacle graph is generated by approximating a mesh around the configuration space obstacle, which is build from the convex hull of its work space counterpart. The supporting graphs are generated by finding the supporting lines between the initial or final position and the mesh. An approximation to the optimal path can subsequently be found using an existing graph search algorithm. The presented approach is suitable for fully known environments with a single truly 3-dimensional (not merely "raised" 2-dimensional) obstacle. An example for generating a nearly minimum

length path for a small-scale helicopter operating near a building is shown.

15:10-16:40 MoPO2S.4

Estimating Driving Behavior by a Smartphone, pp. 234-239

Eren, Haluk — Univ.
Makinist, Semiha — iDaSuCo Res. Firat Univ.
Akin, Erhan — FIRAT Univ.
Yilmaz, Alper — THE OHIO STATE Univ. PCVLab

In this paper, we propose an approach to understand the driver behavior using smartphone sensors. The aim for analyzing the sensory data acquired using a smartphone is to design a car-independent system which does not need vehicle mounted sensors measuring turn rates, gas consumption or tire pressure. The sensory data utilized in this paper includes the accelerometer, gyroscope and the magnetometer. Using these sensors we obtain position, speed, acceleration, deceleration and deflection angle sensory information and estimate commuting safety by statistically analyzing driver behavior. In contrast to state of the art, this work uses no external sensors, resulting in a cost efficient, simplistic and user-friendly system.

15:10-16:40 MoPO2S.5

ACC of Electric Vehicles with Coordination Control of Fuel Economy and Tracking Safety, pp. 240-245

Dang, Ruina — Tsinghua or China North Vehicle Res. Inst.
He, Chaozhe — Beihang Univ.
Zhang, Qiang — Chongqing Changan Automobile (Group) Co.
Li, Keqiang — Tsinghua Univ.
Li, Yusheng — Chongqing Changan Automobile (Group) Co.

Abstract—An adaptive cruise control system of electric vehicles is proposed, considering both fuel economy and tracking safety with model predictive control theory. Firstly, the mathematical relationship between fuel cost and longitudinal acceleration is analyzed through a simulation model. Secondly the 2-norm number is adopted to indicate the integrated cost function, which integrates economy performance and tracking performance together. Finally the proposed optimization problem is solved by model predictive control theory, and a contrast controller is built with linear quadratic algorithm. Both simulation and real vehicle test results show that the MPC controller can reduce fuel cost by above 5% than LQ controller in the range of safe tracking, and it successfully coordinates fuel economy and tracking safety.

15:10-16:40 MoPO2S.6

Generation of High Precision Digital Maps Using Circular Arc Splines, pp. 246-251

Schindler, Andreas — Univ. of Passau
Maier, Georg — FORWISS, Univ. of Passau, Germany
Janda, Florian — Univ. of Passau

Digital maps can provide essential information for many advanced driver assistance systems (ADAS) dedicated to both safety and comfort applications. As the level of detail and global accuracy of state-of-the-art digital maps are not sufficient for a multitude of applications, we present methods and models for the generation of high precision maps. The proposed modeling includes 3D lane level information, road markings, landmarks and additional attributes with benefits for many ADAS. The extensive use of circular arc splines enables both adjustable accuracy and high efficiency as our cartographic methodology guarantees the minimal possible number of curve segments with respect to a given error threshold.

15:10-16:40 MoPO2S.7

StreamCars: A New Flexible Architecture for Driver Assistance Systems, pp. 252-257

Bolles, André — OFFIS - Inst. für Informatik
Appelrath, H.-Jürgen — Univ. Oldenburg
Geesen, Dennis — Univ. Oldenburg
Grawunder, Marco — Univ. Oldenburg
Hannibal, Marco — Deutsches Zentrum für Luft- und Raumfahrt
Jacobi, Jonas — Univ. Oldenburg
Köster, Frank — German Aerospace Center (DLR) Inst. of Transportation System
Nicklas, Daniela — Univ. Oldenburg

One of the main challenges in traffic is to assure safety for all road users. Hence, especially expensive vehicles are equipped with advanced driver assistance systems (ADAS) that use data about the vehicle and information about objects in the proximity of the vehicle to execute the assistance function. These objects have to be detected by sensors and they have to be tracked over multiple scans to keep the object's state up-to-date. Usually, such ADAS are developed as proprietary systems that are tailored for the specific assistance function and the specific sensors in use. Indeed, this leads to a very efficient system. However, changing system properties, e.~g. an exchange of sensors, is very expensive. In this case, very often at least some parts of the system code have to be reimplemented. To solve this problem of bad maintainability, which raises especially during the development of new assistance functions, in this work a new architecture for ADAS is developed. The relevant information for by the assistance function is no longer provided by hard coded, predefined processes but by flexible continuous operator plans in a datastream management system. These operator plans build up a dynamic context model of the vehicle's environment. The context model is kept up-to-date by object tracking operators in these operator plans and is then used as a data source to extract information for different assistance functions. This extraction is also done by operator plans that produce only relevant information and discard other information.

15:10-16:40 MoPO2S.8

Estimating Energy Consumption for Routing Algorithms, pp. 258-263

Kraschl-Hirschmann, Karin — Tech. Univ. Graz
Fellendorf, Martin — Tech. Univ. Graz

Due to increased public discussion on global climate change and increased awareness of environmental issues in general, a variety of transport related strategies are being developed to reduce the energy consumption of road travel. Pre-trip journey planners and on-trip navigation systems are widely used to identify optimal routes. Travel time, trip distance and travel cost are usually used as criteria to search for the best route and suitable alternatives. However, energy use could also be used as a criterion in these systems to identify energy minimizing routes will be one measure to reduce fuel consumption. In order to identify these "eco-friendly" routes, the energy consumption for each link of a network must be computed quickly and precisely. This paper presents an approach for calculating link energy consumption based on the actual power needed to overcome the driving resistance for each link using link travel speeds and v/c-ratios. The proposed method can be embedded in routing algorithms and be used as one component in the optimization of the route algorithm's generalized cost function.

15:10-16:40 MoPO2S.9

Development of a General Criticality Criterion for the Risk Estimation of Driving Situations and Its Application to a Maneuver-Based Lane Change Assistance System, pp. 264-269

Rodemerk, Claas — Tech. Univ. of Darmstadt
Habenicht, Stefan — Tech. Univ. Darmstadt
Weitzel, Alexander — TU Darmstadt
Winner, Hermann — Tech. Univ. Darmstadt
Schmitt, Thomas — TU Darmstadt

The results of a fundamental study on developing a general criticality criterion for driving situations are presented. The meaning of criticality in driving situations is defined and the influencing parameters are analyzed. Furthermore, a maneuver-based lane change assistance system is presented and evaluated in subject tests. The outcomes of the general top-down approach are compared to an evaluation criterion which is the available reaction time for the maneuver-based lane change assistance system, developed in a bottom-up approach.

15:10-16:40 MoPO2S.10

Car2X-Based Perception in a High-Level Fusion Architecture for Cooperative Perception Systems, pp. 270-275

Rauch, Andreas	BMW Group
Klanner, Felix	BMW Group
Rasshofer, Ralph	BMW Forschung und Tech. GmbH
Dietmayer, Klaus	Univ. of Ulm

In cooperative perception systems, different vehicles share object data obtained by their local environment perception sensors, like radar or lidar, via wireless communication. In this paper, this so-called Car2X-based perception is modeled as a virtual sensor in order to integrate it into a high-level sensor data fusion architecture. The spatial and temporal alignment of incoming data is a major issue in cooperative perception systems. Temporal alignment is done by predicting the received object data with a model-based approach. In this context, the CTRA (constant turn rate and acceleration) motion model is used for a three-dimensional prediction of the communication partner's motion. Concerning the spatial alignment, two approaches to transform the received data, including the uncertainties, into the receiving vehicle's local coordinate frame are compared. The approach using an unscented transformation is shown to be superior to the approach by linearizing the transformation function. Experimental results prove the accuracy and consistency of the virtual sensor's output.

15:10-16:40 MoPO2S.11

Road Ortho-Image Generation Based on Accurate Vehicle Trajectory Estimation by GPS Doppler, pp. 276-281

Meguro, Junichi	TOYOTA CENTRAL R&D Lab. INC.
Ishida, Hiroyuki	TOYOTA CENTRAL R&D Lab. INC.
Kidono, Kiyosumi	Toyota Central R&D Lab. Inc.
Kojima, Yoshiko	TOYOTA Central R&D Lab. Inc.

This paper proposes a novel technique to generate accurate road ortho-images using low-cost sensors (single frequency GPS, speed sensor and MEMS yaw rate gyro). Ortho-images are data incorporated into accurate digital maps. Our proposal should contribute to reduction in production costs of accurate digital maps. The most striking feature of our proposal is vehicle trajectory estimation using GPS Doppler, for road image mosaicing. We realize accurate trajectory and heading angle estimation by integrating GPS Doppler and yaw-rate gyro. This enables creation of ortho-images with a combination of devices less expensive than the conventionally used ones. A comparison with commercial road ortho-images shows that our proposed technique can realize the same level of accuracy.

15:10-16:40 MoPO2S.12

Bayesian Network Classifiers Inferring Workload from Physiological Features: Compared Performance, pp. 282-287

Besson, Patricia	UMR CNRS 7287 Aix-Marseille Univ.
Dousset, Erick	Inst. of Movement Sciences, UMR CNRS 7287 Aix-Marseille Uni
Bourdin, Christophe	Inst. of Movement Sciences, UMR CNRS 7287 Aix-Marseille Uni
Bringoux, Lionel	Inst. of Movement Sciences, UMR CNRS 7287 Aix-Marseille Uni
Marqueste, Tanguy	Inst. of Movement Sciences, UMR CNRS 7287 Aix-Marseille Uni
Mestre, Daniel R	Aix-Marseille Univ.
Vercher, Jean-Louis	Inst. of Movement Sciences, UMR CNRS 7287 Aix-Marseille Uni

This paper presents an approach based on Bayesian Networks to estimate the workload of operators. The models take as inputs the entropy of different number of physiological features, as well as a cognitive feature (reaction time to a secondary task). They output the workload variation of subjects involved in successive tasks demanding different levels of cognitive resources. The performances of the classifiers are discussed in term of two criteria to be jointly optimized: the diversity, i.e. the ability of the model to perform on different subjects, and the accuracy, i.e., how close from the (subjectively estimated) workload level the model prediction is.

15:10-16:40 MoPO2S.13

Mobile Application As a Tool for Urban Traffic Data Collection and Generation to Advanced Traveler Information Systems Using Wi-Fi Networks Available in Urban Centers, pp. 288-292

Dezani, Henrique	Univ. of Campinas (UNICAMP)
Damiani, Furio	Univ. of Campinas
Marranghello, Norian	Sao Paulo State Univ. - UNESP
Viudes, Ulysses	Coll. of Tech. of São José do Rio Preto (FATEC)
Parra, Ícaro Augusto	Coll. of Tech. of São José do Rio Preto (FATEC)

This paper presents an Advanced Traveler Information System (ATIS) developed on Android platform, which is open source and free. The developed application has as its main objective the free use of a Vehicle-to-Infrastructure (V2I) communication through the wireless network access points available in urban centers. In addition to providing the necessary information for an Intelligent Transportation System (ITS) to a central server, the application also receives the traffic data close to the vehicle. Once obtained this traffic information, the application displays them to the driver in a clear and efficient way, allowing the user to make decisions about his route in real time. The application was tested in a real environment and the results are presented in the article. In conclusion we present the benefits of this application.

15:10-16:40 MoPO2S.14

Transponder and Camera-Based Advanced Driver Assistance System, pp. 293-298

Westhofen, Daniel	Continental Safety Engineering International GmbH
Gründler, Carolin	Univ. of Applied Sciences Aschaffenburg
Doll, Konrad	Univ. of Applied Sciences Aschaffenburg
Brunsmann, Ulrich	Univ. of Applied Sciences Aschaffenburg
Zecha, Stephan	Continental Safety Engineering International GmbH

Cooperative traffic safety is a straightforward approach for a significant reduction of accidents and fatalities. This paper presents a predictive safety system based on a cooperative localization technology using transponders combined with a monocular camera. By means of these sensor components other traffic partners in the surrounding area are recognized and tracked even in case of occlusion. Using the pedestrian detections of the transponder system for the generation of regions of interest (ROI), video-based confirmation is achieved in real-time using histograms of oriented gradients (HOG). An extended Kalman filter is applied to cope with adapted nonlinear process and measurement models for transponderbased tracking, including methods for compensation of the vehicle's ego motion and sensor mounting offsets. The collision risk with other traffic partners especially pedestrians is assessed by using sophisticated motion models based on empirical data. In an experimental study of real-world scenarios it is demonstrated that the fusion of the sensor data results in a reliable prediction of upcoming collision risks and enables a specific warning or a justified autonomous brake maneuver in order to avoid a collision. The results confirm excellent detection, tracking and real-time performance and emphasize the potential of transponder-based active safety systems.

15:10-16:40 MoPO2S.15

Color Correction for Onboard Multi-Camera Systems Using 3D Gaussian Mixture Models, pp. 299-303

Riem de Oliveira, Miguel Armando	Univ. of Aveiro
Sappa, Angel D.	Computer Vision Center
Santos, Vitor	Univ. of Aveiro

The current paper proposes a novel color correction approach for onboard multi-camera systems. It works by segmenting the given images into several regions. A probabilistic segmentation framework, using 3D Gaussian Mixture Models, is proposed. Regions are used to compute local color correction functions, which are then combined to obtain the final corrected image. An image data set of road scenarios is used to establish a performance comparison of the proposed method with other seven well known color correction algorithms. Results show that the proposed approach is the highest scoring color correction method. Also, the proposed single step 3D color space probabilistic segmentation reduces processing time over similar approaches.

15:10-16:40	MoPO2S.16

Will Intelligent Vehicles Evolve into Human-Peer Robots?, pp. 304-309

Da Lio, Mauro	Univ. of Trento
Biral, Francesco	Univ. of Trento
Galvani, Marco	Univ. of Trento
Saroldi, Andrea	Centro Ricerche Fiat (CRF)

This paper aims at stimulating the discussion on the future of Intelligent Vehicles. It is a position paper, indicating converging technologies that, in our opinion, will have to be used in future Intelligent Vehicles. We present a vision according to which Intelligent Vehicles will evolve into Human-peer Robots, here called Co-Drivers. Co-Drivers will be able to “understand” human drivers and to form symbiotic systems with them. The general architecture of Co-Drivers, the building blocks and the technologies that are needed to bring them to life are discussed, pointing out which parts have been already researched and which gaps still remain. We clarify what “understanding driver” actually means and how a joint system can be obtained. The paper will identify research needs and paths, and hopefully trigger interest.

15:10-16:40	MoPO2S.17

Analyzing Vehicle Traces to Find and Exploit Correlated Traffic Lights for Efficient Driving, pp. 310-315

Kerper, Markus	Volkwagen Group
Wewetzer, Christian	Volkswagen Group
Mauve, Martin	Univ. of Düsseldorf

Traffic lights strongly impact vehicle movement and fuel consumption in cities. If drivers were aware of the situation at arrival time, they could adapt their velocity and thus reduce the number of unnecessary stops and fuel consumption.

To predict the influence of the traffic light ahead on the velocity of an approaching vehicle, our vision is that drivers share their vehicle traces in a digital cloud, and in return benefit from algorithms evaluating the collected data. With *Traffic Light Coordination Analysis* (TLCorA), we present one such algorithm analyzing vehicle traces. When a vehicle is approaching a traffic light, TLCorA finds traces of vehicles similar to that of the vehicle at the previous traffic light, and calculates from their approach to the upcoming traffic light whether there is a representative approaching trace. For this purpose, TLCorA classifies the approaching traces with help of a clustering algorithm based on dynamic time warping.

We implement TLCorA in simulations of different traffic light signalization algorithms, and study the calculated approach probabilities depending on the respective traffic light correlation level in the scenarios.

15:10-16:40	MoPO2S.18

Towards a Generic and Efficient Environment Model for ADAS, pp. 316-321

Grewe, Ralph	Continental Div. Chassis & Safety, Advanced Engineering
Hohm, Andree	Continental Div. Chassis & Safety, Advanced Engineering
Hegemann, Stefan	Continental Div. Chassis & Safety, Advanced Engineering
Lueke, Stefan	Continental Div. Chassis & Safety, Advanced Engineering
Winner, Hermann	Tech. Univ. Darmstadt

In research projects for future ADAS functions a dense environment model covering free space is often necessary, which is obtained by complementing or replacing a common object list by a grid based environment model. The drawbacks of grid based models are their demands for memory, computational resources and bandwidth. This paper analyzes the influence of data compression on accuracy and resource demand of a grid. By using a simple compression scheme the transmission bandwidth and the required computational resources can be significantly reduced.

15:10-16:40	MoPO2S.19

Energy Optimal Control of an Over Actuated Robotic Electric Vehicle Using Enhanced Control Allocation Approaches, pp. 322-327

Brembeck, Jonathan	German Aerospace Center (DLR)
Ritzer, Peter	-

In this paper an energy optimal control strategy for a highly maneuverable Robotic Electric Vehicle (ROboMObil) is presented. The ROMO is a development of the Robotics and Mechatronics Center (which is part of the German Aerospace Center) to cope with several research topics, like energy efficient, autonomous or remote controlled driving for future (electro-) mobility applications. Since saving electric energy is a primal goal when operating a battery electric vehicle (like the ROMO), we have developed a new approach for energy optimal control of an over-actuated electric car. The focus of the control strategy lies in the model based minimization of the actuator losses and power consumption for driving along a precalculated trajectory to optimize the overall efficiency. The approach is based on a real-time capable nonlinear control allocation (CA) algorithm, using quadratic programming, implemented in the object oriented modeling language Modelica. Two optimization objectives are analyzed and the performance is presented by simulation results. Finally an CA extension to nonlinear dynamic inversion is discussed, which is able to compensate the different time constants of the actuators.

15:10-16:40	MoPO2S.20

Improving Lateral Performance of Longer Combination Vehicles – an Approach Based on Eigenstructure Assignment, pp. 328-333

Kharrazi, Sogol	Chalmers Univ. of Tech.
Gordon, Tim	Univ. of Michigan
Lidberg, Mathias	Chalmers Univ. of Tech.

Feasibility of eigenstructure assignment for controlling lateral performance of longer combination vehicles is investigated. As a sample case, a controller is designed for a truck-dolly-semitrailer combination based on partial eigenstructure assignment and frequency response analysis. The results of simulations with a nonlinear vehicle model show significant improvement in lateral performance of the vehicle with the designed controller.

15:10-16:40	MoPO2S.21

Veiling Luminance Estimation on FPGA-Based Embedded Smart Camera, pp. 334-339

Grana, Costantino	DII - Univ. degli Studi di Modena e Reggio Emilia
Borghesani, Daniele	DII - Univ. degli Studi di Modena e Reggio Emilia
Santinelli, Paolo	DII - Univ. degli Studi di Modena e Reggio Emilia
Cucchiara, Rita	Univ. of Modena and Reggio Emilia

This paper describes the design and development of a Veiling Luminance estimation system based on the use of a CMOS image sensor, fully implemented on FPGA. The system is composed of the CMOS Image sensor, FPGA, DDR SDRAM, USB controller and SPI (Serial Peripheral Interface) Flash. The FPGA is used to build a system-on-chip integrating a soft processor (Xilinx MicroBlaze) and all the hardware blocks needed to handle the external peripherals and memory. The soft processor is used to handle image acquisition and all computational tasks need to compute the Veiling Luminance value. The advantages of this single chip FPGA implementation include the reduction of the hardware rquirements, power consumption, and system complexity. The problem of the high dynamic range images have been addressed with multiple acquisitions at different exposure times. Vignetting, radial distortion and angular weighting, as required by veiling luminance definition, are handled by a single integer look-up table (LUT) access. Results are compared with a state of the art

certified instrument.

15:10-16:40	MoPO2S.22

Text Recognition on Traffic Panels from Street-Level Imagery, pp. 340-345

Gonzalez, Alvaro	Univ. of Alcala
Bergasa, Luis M.	Univ. of Alcala
Yebes Torres, José Javier	Univ. of Alcalá
Almazán, Javier	Univ. of Alcalá

Text detection and recognition in images taken in uncontrolled environments still remains a challenge in computer vision. This paper presents a method to extract the text depicted in road panels in street view images as an application to Intelligent Transportation Systems (ITS). It applies a text detection algorithm to the whole image together with a panel detection method to strengthen the detection of text in road panels. Word recognition is based on Hidden Markov Models, and a Web Map Service is used to increase the effectiveness of the recognition. In order to compute the distance from the vehicle to the panels, a function that estimates the distance in meters from the text height in pixels has been obtained. After computing the direction vector of the vehicle, world coordinates are computed for each panel. Experimental results on real images from Google Street View prove the efficiency of our proposal and give way to using street-level images for different applications on ITS such as traffic signs inventory or driver assistance.

15:10-16:40	MoPO2S.23

Safe, Dynamic and Comfortable Longitudinal Control for an Autonomous Vehicle, pp. 346-351

Reschka, Andreas	Univ. Hildesheim
Saust, Falko	Tech. Univ. Braunschweig
Böhmer, Jürgen Rüdiger	Univ. Hildesheim
Lichte, Bernd	Tech. Univ. Braunschweig
Maurer, Markus	TU Braunschweig

Driver assistance systems are commonly available in many vehicles. There are systems for safety functions like the Electronic Stability Control, Automatic Traction Control, Anti-lock Brake System and automatic emergency braking. There are also systems for comfort functions like adaptive cruise control with stop and go functionality and combined safety and comfort functions like lane keeping and side-wind assistance. A control system consisting of all of these systems would allow comfortable automatic vehicle guidance on highways.

In an urban environment, like in the Stadtpilot project, requirements on driver assistance systems are higher, especially in the case of full autonomous driving. An essential part of an autonomous vehicle control system is a longitudinal controller for acceleration and deceleration of the vehicle. This longitudinal control system has to take care of many more conditions than an assistance system. E.g. it needs to perceive and calculate road and weather conditions with its sensors, which usually is a task a human driver does instinctively.

The present paper describes how the autonomous vehicle Leonie is able to adapt its longitudinal control to changing road and weather conditions by calculating a so called Grip Value and gives an outlook how this parameter affects whole vehicle guidance.

15:10-16:40	MoPO2S.24

Off-Vehicle Evaluation of Camera-Based Pedestrian Detection, pp. 352-358

Bar Hillel, Aharon	General Motors
Alon, Yaniv	CVtech LTD

Performance evaluation and comparison of vision-based automotive modules is a growing need in automotive industry. Off-vehicle evaluation, using a database of video streams offers many advantages over on-vehicle evaluation in terms of reduced costs, repeatability and the ability to compare different modules under the same conditions. An off-vehicle evaluation platform for camera based pedestrian detection is presented, enabling evaluation of industrial modules and internally developed algorithms. In order to maintain a single video database despite variability in camera location and internal parameters, experiments were done with video warping techniques, in which a video is warped to look as if taken from a target camera. To obtain ground truth annotation, both manual and Lidar-based methods were tested. Lidar-based annotation was shown to achieve detection rate $>80%$ without human intervention, which can go up to $97.5%$ using a semi-supervised methodology with moderate human effort. Finally, we examined several performance metrics, and found that the image-based detection criteria used in most of the literature does not fit certain automotive application well. A modified criterion based on real world coordinates is suggested.

15:10-16:40	MoPO2S.25

Lane Keeping and Lane Departure Avoidance by Rear Wheels Steering, pp. 359-364

Minoiu Enache, Nicoleta	RENAULT SAS
Guegan, Stephane	RENAULT SAS
Desnoyer, François	RENAULT SAS
Vorobieva, Hélène	RENAULT SAS

The driver active assistances have gained recently in importance and become usual features in commercialized vehicles. Nevertheless, the sharing of the vehicle control with the driver, especially for the steering assistances, is an open issue. The rear wheels steering could be an answer to this question. This study contains the development of a control law for the rear steering able to provide lane departure avoidance and lane keeping. The design of the control law is casted as a LMI (Linear Matrix Inequality) optimization problem in order to take into account constraints, as the rear steering actuator limitation. A modulation factor is added to allow a flexible activation strategy of the rear steering assistance. Preliminary simulation results are presented to explain the concept.

15:10-16:40	MoPO2S.26

Grid-Based DBSCAN for Clustering Extended Objects in Radar Data, pp. 365-370

Kellner, Dominik	Univ. of Ulm
Klappstein, Jens	Daimler AG
Dietmayer, Klaus	Univ. of Ulm

The online observation using high-resolution radar of a scene containing extended objects imposes new requirements on a robust and fast clustering algorithm. This paper presents an algorithm based on the most cited and common clustering algorithm: DBSCAN. The algorithm is modified to deal with the non-equidistant sampling density and clutter of radar data while maintaining all its prior advantages. Furthermore, it uses varying sampling resolution to perform an optimized separation of objects at the same time it is robust against clutter. The algorithm is independent of difficult to estimate input parameters such as the number or shape of available objects. The algorithm outperforms DBSCAN in terms of speed by using the knowledge of the sampling density of the sensor (increase of app. 40-70%). The algorithm obtains an even better result than DBSCAN by including the Doppler and amplitude information (unitless distance criteria).

15:10-16:40	MoPO2S.27

Dealing with Occlusions with Multi Targets Tracking Algorithms for the Real Road Context, pp. 371-376

Lamard, Laetitia	Univ. Blaise Pascal and Renault
Chapuis, Roland	LASMEA
Boyer, Jean-Philippe	Renault

In this paper, we present a robust approach to occlusion problems for tracking vehicle and pedestrian on road context. Most multi-target tracking algorithms, like Multiple Hypothesis Tracker (MHT) or Cardinalized Probability Hypothesis Density (CPHD), are based on a sensor detection probability map. This paper proposes to solve the occlusion issue by modifying this detection probability map.We assume targets occlusion is provided by other targets and are treated as non detection event. The new detection probability map is computed by taking into account the width and the imprecision of the position of the targets that hide the others. Our system has been validated with simulated data and also with real measurements from a smart camera sensor embedded in a real car for road context.

15:10-16:40 MoPO2S.28

Fuzzy Takagi-Sugeno LQ Controller for Lateral Control Assistance of a Vehicle, pp. 377-382

Soualmi, Boussaad — LAMIH, Valenciennes Univ.
Sentouh, Chouki — LAMIH/CNRS Univ. of Valenciennes
Popieul, Jean-Christophe — Univ. de Valenciennes
Debernard, Serge — Univ. of Valenciennes/LAMIH

This paper describes a concept of lane keeping assistance system based on the fuzzy Takagi-Sugeno (T-S) optimal controller. Nonlinearities due to longitudinal velocity variation in the lateral dynamics are considered to give a T-S representation and Linear Matrix Inequalities (LMI) are used to reach the appropriate T-S optimal controller that insure the global stability of the closed loop system. In conclusion the effectiveness of the proposed approach is illustrated in Matlab/Simulink and experimental tests carried out on the ”SHERPA” (Simulateur Hybride d'Etude et de Recherche de PSA pour l'Automobile) simulator.

MoOR3S Room T1

Vehicle Control (Regular Session)

Chair: Anderson, Sterling — Massachusetts Inst. of Tech.

16:40-17:00 MoOR3S.1

Constraint-Based Planning and Control for Safe, Semi-Autonomous Operation of Vehicles, pp. 383-388

Anderson, Sterling — Massachusetts Inst. of Tech.
Karumanchi, Sisir — Massachusetts Inst. of Tech.
Iagnemma, Karl — Massachusetts Inst. of Tech.

This paper presents a new approach to semi-autonomous vehicle hazard avoidance and stability control, based on the design and selective enforcement of constraints. This differs from traditional approaches that rely on the planning and tracking of paths. This emphasis on constraints facilitates “minimally-invasive” control for human-machine systems; instead of forcing a human operator to follow an automation-determined path, the constraint-based approach identifies safe homotopies, and allows the operator to navigate freely within them, introducing control action only as necessary to ensure that the vehicle does not violate safety constraints. The method evaluates candidate homotopies based on “restrictiveness”, rather than traditional measures of path goodness, and designs and enforces requisite constraints on the human's control commands to ensure that the vehicle never leaves the controllable subset of a desired homotopy. Identification of these homotopic classes in off-road environments is performed using geometric constructs. The goodness of competing homotopies and their associated constraints is then characterized using geometric heuristics. Finally, input limits satisfying homotopy and vehicle dynamic constraints are enforced using threat-based feedback mechanisms to ensure that the vehicle avoids collisions and instability while preserving the human operator's situational awareness and mental models. The methods developed in this work are shown in simulation and experimentally demonstrated in safe, high-speed teleoperation of an unmanned ground vehicle.

17:00-17:20 MoOR3S.2

Reference Generation and Control Strategy for Automated Vehicle Guidance, pp. 389-394

Attia, Rachid — Univ. de Haute-Alsace
Daniel, Jeremie — Univ. of Haute Alsace
Lauffenburger, Jean-Philippe — Univ. of Haute-Alsace
Orjuela, Rodolfo — Univ. de Haute-Alsace
Basset, Michel — Univ. of Haute-Alsace

This paper describes a vehicle guidance strategy with a focus placed on the reference generation and the control levels. Further to a perception step, performed through the fusion of a Geographic Information System (GIS) and a vision system, the reference generation leads to the computation of a constrained smooth trajectory and a smooth speed profile integrating safety and comfort criteria. The obtained reference set is then used by a longitudinal and NLMPC-based lateral controller providing the steering angle and traction torque. The complete system performance are presented through simulation results based on real-time measurements.

17:20-17:40 MoOR3S.3

Backstepping Based Approach for the Combined Longitudinal-Lateral Vehicle Control, pp. 395-400

Nehaoua, Lamri — IBISC Lab.
Nouveliere, Lydie — IBISC/Univ. of Evry - LCPC/LIVIC

This paper presents an integrated control method of a light road vehicle driving on a known and high secured itinerary at low speed. A planning module sends a safe and low energy reference trajectory to a control module that permits to manage the trajectory tracking under 50 km/h. A backstepping procedure is presented and formulated to realize a coupled longitudinal and lateral control in lane change or collision avoidance maneuvers.

TuPO3S Room T1

Poster Session III (Poster Session)

Chair: Olaverri Monreal, Cristina — Faculty of Mechanical Engineering, Tech.

09:50-11:20 TuPO3S.1

Pushing the Limits of Stereo Using Variational Stereo Estimation, pp. 401-407

Ranftl, Rene — Univ. of Tech. Graz, ICG
Gehrig, Stefan — Daimler AG
Pock, Thomas — Univ. of Tech. Graz, ICG
Bischof, Horst — Graz Univ. of Tech.

We examine high accuracy stereo estimation for binocular sequences that where obtained from a mobile platform. The ultimate goal is to improve the range of stereo systems without altering the setup. Based on a well-known variational optical flow model, we introduce a novel stereo model that features a second-order regularization, which both allows sub-pixel accurate solutions and piecewise planar disparity maps. The model incorporates a robust fidelity term to account for adverse illumination conditions that frequently arise in real-world scenes. Using several sequences that were taken from a mobile platform we show the robustness and accuracy of the proposed model via novel-view prediction on a trinocular data set.

09:50-11:20 TuPO3S.2

Medium Access Control Based on a Non Cooperative Cognitive Radio for Platooning Communications, pp. 408-413

Manzano, Mario — Univ. of Alcala. Pol. School.
Espinosa, Felipe — Univ. of Alcala. Pol. School.
Bravo, Ángel M. — Carlos III Univ. Pol. School.
Garcia, David — Univ. of Alcala. Pol. School.
Gardel, Alfredo — Univ. of Alcala. Pol. School.
Bravo, Ignacio — Univ. of Alcala. Pol. School.

The emergence of Intelligent Transport Systems has led to the development of a specific communications standard carried out by the IEEE: Wireless Access in Vehicular Environments (WAVE). However, this standard does not address certain critical security and real time application constraints, such as the platooning guidance of transport units. This paper presents an original proposal of medium access control protocol based on Non Cooperative Cognitive Radio techniques to obtain a mechanism which complies with the requirements of real time communications. The mechanism also offers other advantages, such as avoiding signalling and the capacity to adapt to channel conditions. The solution is applied to the problem of units merging a convoy. Comparison results between the proposal and Slotted-Aloha are included.

09:50-11:20 TuPO3S.3

A Comparison of Two Different Tracking Algorithms Is Provided for Real Application, pp. 414-419

Lamard, Laetitia — Univ. Blaise Pascal and Renault
Chapuis, Roland — LASMEA
Boyer, Jean-Philippe — Renault

The Multiple Hypothesis Tracker (MHT) and the Cardinalized Probability Hypothesis Density (CPHD) are two algorithms which can overcome the Multi-Targets Tracking (MTT) issues in automotive applications. This paper describes the performance of such algorithms and, in particular the Gaussian Mixture Probability Hypothesis Density (GMPHD) filter and the Track Oriented Multiple Hypothesis Tracker (TOMHT) for multiple cars and humans tracking in real road context. The scenario under consideration is the tracking an unknown number of real targets (humans and vehicles), using real measurements from an intelligent camera and a radar. The estimation of the number of targets and the target states of each filter will allow us to draw conclusion regarding the behavior of TOMHT and GMCPHD in real road context.

09:50-11:20	TuPO3S.4

An Image-To-Image Loop-Closure Detection Method Based on Unsupervised Landmark Extraction, pp. 420-425

Sariyanidi, Evangelos	Istanbul Tech. Univ.
Sencan, Onur	istanbul Tech. Univ.
Temeltas, Hakan	Istanbul Tech. Univ.

This paper presents a dedicated approach to detect loop closures using visually salient patches. We introduce a novel, energy maximization based saliency detection technique which has been used for unsupervised landmark extraction. We explain how to learn the extracted landmarks on-the-fly and re-identify them. Furthermore, we describe the sparse location representation we use to recognize previously seen locations in order to perform reliable loop closure detection. The performance of our method has been analyzed both on an indoor and an outdoor dataset, and it has been shown that our approach achieves quite promising results on both datasets.

09:50-11:20	TuPO3S.5

An Improved Driver-Behavior Model with Combined Individual and General Driving Characteristics, pp. 426-431

Angkititrakul, Pongtep	Nagoya Univ.
Miyajima, Chiyomi	Nagoya Univ.
Takeda, Kazuya	Nagoya Univ.

In this paper, we propose a stochastic driver-behavior modeling framework which takes into account both individual and general driving characteristics as one aggregate model. Patterns of individual driving styles are modeled using Dirichlet process mixture model, a non-parametric Bayesian approach which automatically selects the optimal number of model components to fit sparse observations of each particular driver's behavior. In addition, general or background driving patterns are also captured with a Gaussian mixture model using a reasonably large amount of development observed data from several drivers. By combining both probability distributions, the aggregate driver-dependent model can better emphasize driving characteristics of each particular driver, while also backing off to exploit general driving behavior in cases of unmatched parameter spaces from individual training observations. The proposed driver-behavior model was employed to anticipate pedal-operation behavior during car-following maneuvers involving several drivers on the road. The experimental results showed advantages of the combined model over the adapted model previously proposed.

09:50-11:20	TuPO3S.6

3D Outline Contours of Vehicles in 3D-LIDAR-Measurements for Tracking Extended Targets, pp. 432-437

Steinemann, Philipp	Daimler AG
Klappstein, Jens	Daimler AG
Dickmann, Jürgen	Daimler AG
Wuensche, Hans Joachim	Department of Aerospace
von Hundelshausen, Felix	Univ. of the Bundeswehr Munich

Tracking of extended targets in high definition 360 degree 3D-LIDAR (Light Detection and Ranging) measurements is a challenging task. It is a key component in robotic applications and is relevant to collision avoidance and autonomous driving. This paper presents a robust method to determine the 3D outline contour of vehicles in disordered 3D-LIDAR measurements while using several geometrical vehicle-specific constraints. In addition, the 3D outline contour contains information on the local reliability of the contour. A weighted registration approach allows calculating the velocity of consecutive 3D outline contours directly. The approach is tested with real sensor data. A robot car equipped with an inertial measurement unit serves as ground truth.

09:50-11:20	TuPO3S.7

Impact of Out-Of-Sequence Measurements on the Joint Integrated Probabilistic Data Association Filter for Vehicle Safety Systems, pp. 438-443

Westenberger, Antje	Daimler AG
Duraisamy, Bharanidhar	Daimler AG
Munz, Michael	Daimler AG
Muntzinger, Marc	Daimler AG
Fritzsche, Martin	Daimler AG
Dietmayer, Klaus	Univ. of Ulm

This paper addresses the problem of joint state and existence estimation in the presence of temporally asynchronous measurements. In multi-sensor fusion, the problem can occur that measurements from different sensors can arrive at the processing unit out of sequence, i.e., the original temporal order of the measurements is lost. For the first time, the influence of these out-of-sequence measurements on state estimation as well as on existence estimation is examined. The existence probabilities are estimated via the Joint Integrated Probabilistic Data Association Filter (JIPDA). Two different methods to deal with out-of-sequence measurements in JIPDA are described and compared. It is shown that the handling of out-of-sequence measurements has a considerable influence not only on state, but also on existence estimation.

09:50-11:20	TuPO3S.8

Visual Ego Motion Estimation in Urban Environments Based on U-V Disparity, pp. 444-449

Musleh Lancis, Basam	Univ. Carlos III of Madrid
Martin Gomez, David	Carlos III Univ. of Madrid
de la Escalera, Arturo	Univ. Carlos III de Madrid
Armingol Moreno, José María	Univ. Carlos III de Madrid

The movement of the vehicle provides useful information for different applications, such as driver assistant systems or autonomous vehicles. This information can be known by means of a GPS, but there are some areas in urban environments where the signal is not available, for example: tunnels or streets where there are high buildings. A new method for 2D visual ego motion estimation in urban environments is presented in this paper. This method is based on a stereo- vision system where the feature road points are tracked frame to frame in order to estimate the movement of the vehicle, avoiding outliers from dynamic obstacles. The road profile is used to obtain the world coordinates of the feature points as a unique function of its left image coordinates. For these reasons it is only necessary to search feature points in the lower third of the left images. Moreover, the Kalman filter is used as a solution for filtering or prediction problem. That is, in some cases, it is necessary to filter raw data due to noise acquisition of time series. The results of the ego motion are compared with raw data from a GPS.

09:50-11:20	TuPO3S.9

Lateral Stability Analysis of On-Road Vehicles Using the Concept of Lyapunov Exponents, pp. 450-455

Sadri, Sobhan	The Univ. of Manitoba
Wu, Christine Qiong	Univ. of Manitoba

This paper deals with the application of the concept of Lyapunov exponents in vehicle lateral stability analysis. The constructive nature of the available methods for calculating Lyapunov exponents as the ‘invariant' measure of the dynamics is the main advantage of this concept. The vehicle model has two degrees of freedom (2-DOF), and its non-linearity is caused by the third-order polynomial expression between the sideslip forces on the tires and the tire sideslip angles. In this paper, firstly, the concept of Lyapunov exponents and the standard algorithm to calculate them are presented. Then, by applying this concept to the case of a straight-line motion, the lateral stability region of the vehicle model is estimated. Moreover, the effects of driving conditions such as the vehicle longitudinal velocity, road friction and steering angle on the stability region are investigated. The comparison of the results obtained by the concept of Lyapunov exponents with those given in literature by simulation based methods verifies the effectiveness of this concept for vehicle lateral stability analysis.

09:50-11:20 TuPO3S.10

3D LIDAR Point Cloud Based Intersection Recognition for Autonomous Driving, pp. 456-461

Zhu, Quanwen Wuhan Univ.
Chen, Long Wuhan Univ.
Li, Qingquan Wuhan Univ.
Li, Ming Wuhan Univ.
Nuechter, Andreas Jacobs Univ. Bremen
Wang, Jian WuHan Univ.

Finding road intersections in advance is crucial for navigation and path planning of moving autonomous vehicles, especially when there is no position or geographic auxiliary information available. In this paper, we investigate the use of a 3D point cloud based solution for intersection and road segment classification in front of an autonomous vehicle. It is based on the analysis of the features from the designed beam model. First, we build a grid map of the point cloud and clear the cells which belong to other vehicles. Then, the proposed beam model is applied with a specified distance in front of autonomous vehicle. A feature set based on the length distribution of the beam is extracted from the current frame and combined with a trained classifier to solve the road-type classification problem (segment and intersection). In addition, we also make the distinction between +-shaped and T-shaped intersections. The results are reported over a series of real world data. A performance of above 80% correct classification is reported at a real-time classification rate of 5 Hz.

09:50-11:20 TuPO3S.11

Nature-Inspired Multiple Vehicle Driving Control for Traffic Flow Efficiency: Requirements and Algorithms, pp. 462-468

Kim, Seongwoo Seoul National Univ.
Gwon, Gipoong Seoul National Univ.
Seo, Seungwoo Seoul National Univ.

The dynamics of multi-agent in nature have been largely studied for a long time to investigate how the aggregation of agents can move smoothly in complex environments without collision. The main insights can be summarized such that the aggregated dynamics of animals and particles can be explained by an individual's simple rules. In a similar vein, we conjecture that such simple rules for vehicle maneuvering can accommodate the fluid flow of traffic and reduce car accidents in highway and urban areas. In this paper, we first show the Reynolds' three rules are applicable to autonomous driving on a single lane. Moreover, we provide additional requirements and algorithms for multiple lanes. Based on these results, we show that the proposed nature-inspired driving maneuver can increase traffic flow by 1) mitigating shockwave at bottlenecks and 2) extending the perception range for better path planning, which requires the support of the vehicle autonomy and wireless communication, respectively. Finally, we prove th feasibility of our work with experiments using multiple UAVs.

09:50-11:20 TuPO3S.12

Safety of Stereo Driver Assistance Systems, pp. 469-475

Khan, Waqar Ahmed The Univ. of Auckland
Morris, John Univ. of Auckland

The discrete nature of disparities observed by stereo systems results in complex behaviour of speeds measured by them and affects the efficacy of a stereo based driver assistance system. We describe a tool for a safety engineer which permits the safety of these systems to be estimated. It is based on a model which considers the true error in measured velocities of objects. Outputs from this tool show that choice of stereo system parameters so as to judiciously place the disparity change boundaries is critical to the effectiveness of such a system because the range of possible trajectories for a (possibly colliding) object reduces significantly when a feature point on that object crosses one of these boundaries. This factor also means that larger objects (e.g. trucks) are slightly better tracked by stereo than smaller ones (e.g. signs and pedestrians). Completely safe stereo based systems are also shown to issue many precautionary (and ultimately unnecessary) warnings if the stereo parameters are not chosen carefully.

09:50-11:20 TuPO3S.13

Incorporating Environmental Knowledge into Bayesian Filtering Using Attractor Functions, pp. 476-481

Alin, Andreas Univ. Tübingen
Butz, Martin V. Univ. of Tübingen
Fritsch, Jannik Honda Res. Inst. Europe GmbH

Many automotive systems use linear approaches to track and predict other traffic participants. While this may be appropriate on highways, linear predictions do not work properly on curved roads or lane crossings. This contribution introduces a generic way for including environmental knowledge – such as the lane trajectory ahead – to anticipate yaw rate and acceleration of other traffic participants. The anticipatory knowledge is used to improve prediction in filtering tasks. It is embedded in a Bayesian framework by introducing attractors, which modify the probabilistic propagation of state estimations. The attractors model how traffic participants typically behave, given environmental knowledge such as lane information, traffic lights, or indicator lights. We demonstrate the potential of this approach by modeling the fact that vehicles usually stay in their lane. We show that given correct context information and nonlinear traffic situations, the tracking error is considerably lower compared to conventional tracking methods. In addition, we also show that the intentions of other traffic participants may be derived by comparing the predictions of the probabilistic model given alternative attractors.

09:50-11:20 TuPO3S.14

Probabilistic Localization Method for Trains, pp. 482-487

Heirich, Oliver DLR German Aerospace Center
Robertson, Patrick DLR
Cardalda García, Adrián DLR
Strang, Thomas German Aerospace Center (DLR)
Lehner, Andreas German Aerospace Center (DLR)

The localization of trains in a railway network is necessary for train control or applications such as autonomous train driving or collision avoidance systems. Train localization is safety critical and therefore the approach requires a robust, precise and track selective localization. Satellite navigation systems (GNSS) might be a candidate for this task, but measurement errors and the lack of availability in parts of the railway environment do not fulfill the demands for a safety critical system. Therefore, additional onboard sensors, such as an inertial measurement unit (IMU), odometer and railway feature classification sensors (e.g. camera) are proposed. In this paper we present a top-down train localization approach from theory. We analyze causal dependencies and derive a general Bayesian filter. Furthermore we present a generic algorithm based on particle filter in order to process the multi-sensor data, the train motion and a known track map. The particle filter estimates a topological position directly in the track map without using map matching techniques. First simulations with simplified particular state and measurement models show encouraging results in critical railway scenarios.

09:50-11:20 TuPO3S.15

InfraCall : Ecall for the Infrastructure, pp. 488-493

Dupin, Francis IFSTTAR
Andrieu, Cindie IFSTTAR
Besnier, Joëlle IFSTTAR
Duplan, Félicien IFSTTAR

This paper presents a **full chain to detect the accidents from the infrastructure** . This work is the result of the collaborative project *InfraCall*. It focuses on the protection of the crash cushions and barrier rails. The principle is to adapt on them sensors and to take a photo. The informations are instantly transmitted to an emergency call center. After having described the system, we presents a costs benefits analysis based on a study of the accidentology in the suburbs of Paris.

09:50-11:20	TuPO3S.16

Data Fusion for Overtaking Vehicle Detection Based on Radar and Optical Flow, pp. 494-499

Garcia, Fernando	Univ. Carlos III de Madrid
Cerri, Pietro	Univ. of Parma
Broggi, Alberto	Univ. of Parma
de la Escalera, Arturo	Univ. Carlos III de Madrid
Armingol Moreno, José María	Univ. Carlos III de Madrid

Trustworthiness is a key point when dealing with vehicle safety applications. In this paper an approach to a real application is presented, able to fulfill the requirements of such demanding applications. Most of commercial sensors available nowadays are usually designed to detect front vehicles but lack the ability to detect overtaking vehicles. The work presented here combines the information provided by two sensors, a Stop&Go radar and a camera. Fusion is done by using the unprocessed information from the radar and computer vision based on optical flow. The basic capabilities of the commercial systems are upgraded giving the possibility to improve the front vehicles detection system, by detecting overtaking vehicles with a high positive rate.

09:50-11:20	TuPO3S.17

Roll Angle Estimation for Motorcycles: Comparing Video and Inertial Sensor Approaches, pp. 500-505

Schlipsing, Marc	Ruhr-Univ. Bochum
Salmen, Jan	Ruhr-Univ. Bochum
Lattke, Benedikt	Tech. Univ. Darmstadt
Schröter, Kai Gerd	Tech. Univ. Darmstadt
Winner, Hermann	Tech. Univ. Darmstadt

Advanced Rider Assistance Systems (ARAS) for powered two-wheelers improve driving behaviour and safety. Further developments of intelligent vehicles will also include video-based systems, which are successfully deployed in cars. Porting such modules to motorcycles, the camera pose has to be taken into account, as e.g. large roll angles produce significant variations in the recorded images. Therefore, roll angle estimation is an important task for the development of various kinds of ARAS. This study introduces alternative approaches based on inertial measurement units (IMU) as well as video only. The latter learns orientation distributions of image gradients that code the current roll angle. Until now only preliminary results on synthetic data have been published. Here, an evaluation on real video data will be presented along with three valuable improvements and an extensive parameter optimisation using the Covariance Matrix Adaptation Evolution Strategy. For comparison of the very dissimilar approaches a test vehicle is equipped with IMU, camera and a highly accurate reference sensor. The results state high performance of about 2 degrees error for the improved vision method and, therefore proofs the proposed concept on real-world data. The IMU-based Kalman filter estimation performed on par. As a naive result averaging of both estimates already improved performance an elaborate fusion of the proposed methods is expected to yield further improvements.

09:50-11:20	TuPO3S.18

Design of a Universal Self-Driving System for Urban Scenarios -BIT-III in the 2011 Intelligent Vehicle Future Challenge, pp. 506-510

Jiang, Yan	Beijing Inst. of Tech.
Zhao, Xijun	Beijing Inst. of Tech.
Gong, Jianwei	Massachusetts Inst. of Tech.
Xiong, Guangming	Beijing Inst. of Tech.
Chen, Huiyan	Beijing Inst. of Tech.
Zhai, Yong	Beijing Inst. of Tech.
Jiang, Yanhua	Beijing Inst. of Tech.
Zhou, Shengyan	Beijing Inst. of Tech.
Hu, Yuwen	Beijing Inst. of Tech.

the 2011 Intelligent Vehicle Future Challenge (11'IVFC) tested self-driving systems in real urban scenarios. The entry of Beijing Institute of Technology: BIT-III finished the 10-kilometer long track in 28 minutes without human operation and obeyed traffic regulations in most circumstances. This paper presented the design and implementation of BIT-III. As a universal self-driving system, BIT-III valued extensibility and featured modularized system architecture. For a better compatibility with diverse sensing devices, BIT-III classified perception to be either OGM-oriented or object-oriented based on the output mode. To work in environments with uncertainties, BIT-III gave first priority to safety and stability in driving, and realized them in the core-level components as the instinct of the system. Even in the unknown environment in the 11'IVFC, BIT-III was able to drive smoothly without crashes.

09:50-11:20	TuPO3S.19

Parsimonious Real Time Monocular SLAM, pp. 511-516

Bresson, Guillaume	LASMEA - Univ. Blaise Pascal
Féraud, Thomas	LASMEA - Univ. Blaise Pascal
Aufrere, Romuald	Blaise Pascal Univ.
Checchin, Paul	Univ. Blaise Pascal - Clermont-Ferrand - FRANCE
Chapuis, Roland	LASMEA

This paper presents a real time monocular EKF SLAM process that uses only Cartesian defined landmarks. This representation is easy to handle, light and consequently fast. However, it is prone to linearization errors which can cause the filter to diverge. Here, we will first clearly identify and explain when those problems take place. Then, a solution, able to reduce or avoid the errors involved by the linearization process, will be proposed. Combined with an EKF, our method uses resources parsimoniously by conserving landmarks for a long period of time without requiring many points to be efficient. Our solution is based on a method to properly compute the projection of a 3D uncertainty into the image frame in order to track landmarks efficiently. The second part of this solution relies on a correction of the Kalman gain that reduces the impact of the update when it is incoherent. This approach was applied to a real data set presenting difficult conditions such as important distortions, reflections, blur or sunshine to illustrate its robustness.

09:50-11:20	TuPO3S.20

Platooning with DSRC-Based IVC-Enabled Autonomous Vehicles: Adding Infrared Communications for IVC Reliability Improvement, pp. 517-522

Fernandes, Pedro	Inst. of Systems and Robotics
Nunes, Urbano	Univ. de Coimbra

Platooning with IVC-enabled autonomous vehicles may enable a significant increase in lane capacity, if performed with constant spacing policies. However, to be effective, such system is very demanding with respect to communication performance and reliability. Dedicated short range communications (DSRC) is the prominent intervehicle communication (IVC) technology. However, its reliability rises concerns when operating under platooning scenarios. In this paper we identify some specific problems that platooning pose to DSRC, through the simulation of several scenarios implemented in the NS-3 network simulator. Moreover, we propose a new concept of IVC when applied to platoons, using simultaneously two different communication technologies: DSRC and infrared (IR). New guidelines toward more efficient use of IVC transmission media are suggested, e.g., by broadcasting the event-driven type of messages through DSRC, whereas periodic vehicle control-based messages use the IR channel, in unicast. Furthermore, the base architecture of the IVC proposed system is presented.

09:50-11:20	TuPO3S.21

A Decentralized Smartphone Based Traffic Information System, pp. 523-528

Picone, Marco	Univ. of Parma
Amoretti, Michele	Univ. degli Studi di Parma
Zanichelli, Francesco	Univ. of Parma

Location-Based Services (LBSs) are information or entertainment services where the request, the response and served contents depend on the physical position of the requesting device. LBS are frequently used to implement Traffic Information Systems (TIS), which

are increasingly based on user-contributed information. In this paper we present the first prototype of our solution for a decentralized, smartphone- based TIS, called D4V, that allows each participant vehicle to efficiently discover data or services located near any chosen geographic position. The experimental evaluation has shown that D4V could be effectively used on the road to reduce the number of drivers involved in traffic jams, as well as to disseminate alert messages about potentially dangerous road stretches, thus allowing drivers to reduce risks and nuisances along their paths.

09:50-11:20 TuPO3S.22

Cooperative Driving: Beyond V2V As an ADAS Sensor, pp. 529-534

Caveney, Derek	Toyota Motor Engineering & Manufacturing North America,Inc.
Dunbar, William B.	Univ. of California, Santa Cruz

Vehicle-to-Vehicle (V2V) communication systems utilize wireless communications for shared sensing between vehicles. This paper discusses how V2V systems could be utilized, beyond shared sensing, for shared decision making between cooperative vehicles. We propose distributed receding horizon control (DRHC) as an appropriate mechanism for scalable, shared decision making. Two automated driving applications, platooning and cooperative merging, illustrate the use of essential enabling technologies, including geo-spatial positions, digital road maps, collision avoidance, and path prediction, and how each is incorporated through our DRHC-centric framework. At the core of the framework is a four-task logic that allows partially-synchronous execution of local, computationally-efficient, optimization problems on board each vehicle.

09:50-11:20 TuPO3S.23

Improving Situational Awareness with Radar Information, pp. 535-540

Clarke, Bryan	Univ. of Sydney
Worrall, Stewart	Univ. of Sydney
Brooker, Graham	USYD
Martinez, Javier Carlos	Univ. of Sydney
Nebot, Eduardo	ACFR Univ. of Sydney

This paper addresses the issue of improving situational awareness for large vehicles operating in all weather conditions. A new short-range 24GHz close proximity detection (CPD) microwave radar technology for providing situational awareness to the driver of large vehicles is presented. A series of experiments are performed in which the radar is used to detect a variety of static targets. The CPD radar is able to detect light vehicles at ranges from 2.2m to 17.6m within a horizontal arc of 160 degrees with superior angular resolution to many existing low-cost radars. From this data, key characteristics of the radar's performance and the radar cross-section of light vehicles at 24GHz are calculated. The data gathered allows the design of future tests and the development of a model of the radar that allows a better understanding of its performance characteristics and can be used for occupancy grid mapping.

09:50-11:20 TuPO3S.24

Up to the Limits: Autonomous Audi TTS, pp. 541-547

Langer, Dirk	Volkswagen of America
Funke, Joseph	Stanford Univ.
Theodosis, Paul	Stanford Univ.
Hindiyeh, Rami	Stanford Univ.
Kritayakirana, Krisada	Stanford Univ.
Gerdes, Chris	Stanford Univ.
Mueller-Bessler, Bernhard	Audi AG
Huhnke, Burkhard	Volkswagen AG
Hernandez, Marcial	Volkswagen
Stanek, Ganymed	Stanford Univ.

This paper presents a novel approach to autonomous driving at the vehicle's handling limits. Such a system requires a high speed, consistent control signal as well as numerous safety features capable of monitoring and stopping the vehicle. When operating, the system's high level controller utilizes a highly accurate differential GPS and known friction values to drive a precomputed path at the friction limits of the vehicle. The system was tested in a variety of road conditions, including the challenging Pikes Peak Hill climb. Results from this work can be extended to improve driving safety and accident avoidance in vehicles.

09:50-11:20 TuPO3S.25

A Lasers and Cameras Calibration Procedure for VIAC Multi-Sensorized Vehicles, pp. 548-553

Mazzei, Luca	Parma Univ.
Medici, Paolo	Univ. di Parma
Panciroli, Matteo	Univ. di Parma

This paper proposes an efficient calibration procedure designed for the vehicle prototypes involved in the VisLab Intercontinental Autonomous Challenge. The perception system is based on laser rangefinders and cameras, for their complementary purpose. High precision pose estimation must be done by such a calibration procedure in order to convert information between different coordinate systems. A modular approach has been extensively tested during VIAC which has offered a unique chance to face pros and cons of different calibration procedures; data collected during the expedition has also become a reference benchmark for further improvements.

09:50-11:20 TuPO3S.26

Study on Active Steering Control of Vehicle for Safe Driving in Highway with GPS Information, pp. 554-557

Lee, Kwang-Hee	Inha Univ.
Bak, Jeong-Hyeon	Inha Univ.
Lee, Chul-Hee	Inha Univ.

In recent days, vehicles have become equipped with electric system that assist and help drivers driving safe in highway. Lane Departure Warning and Lane Keeping Assistant System are one of those safe system. Sudden and inattentive lateral motion of vehicle due to drivers' fatigue, illness, inattention, and drowsiness are major causes of accidents in highway. In order to prevent and minimize any possible accidents due to lateral motion of vehicle, active steering control system is designed and simulated in this study. Activation and warning areas are defined for the control system with respect to the location of vehicle and parameters for vehicle dynamics. The current location of vehicle is obtained by Differential Global Positioning System (DGPS) and it can detect DGPS-based lanes then determine whether activates or not.

09:50-11:20 TuPO3S.27

Predictive Maneuver Evaluation for Enhancement of Car-To-X Mobility Data, pp. 558-564

Firl, Jonas	Adam Opel AG
Stübing, Hagen	Adam Opel AG
Huss, Sorin Alexander	Tech. Univ. Darmstadt
Stiller, Christoph	Karlsruhe Inst. of Tech.

Advanced Driver Assistance Systems (ADAS) employ single object information to provide safety, comfort, or infotainment features. The required data is mainly extracted from external sensors to recognize and predict the future states of relevant traffic participants. Next generation ADAS will also use data from additional sources like, e.g., Car-to-X communication networks, to avoid some typical restrictions of common sensor setups. In this work, we present a method, which uses information on other traffic participants, and furthermore recognizes and considers their interactions in terms of traffic maneuvers to better predict their states. For this purpose, a probabilistic framework is presented, which recognizes object interactions as well as different road characteristics by introducing local, adaptive occupancy grids. The resulting maneuver recognition is shown to considerably improve received mobility data in terms of position, speed, and heading. These concepts have been fully implemented and evaluated by means of real world experiments.

TuOR1S Room T1

Vehicle Environment Perception (Regular Session)

Chair: Franke, Uwe	Daimler AG

11:20-11:40 TuOR1S.1

May I Enter the Roundabout? a Time-To-Contact Computation Based on Stereo Vision, pp. 565-570

Muffert, Maximilian	Daimler AG

Milbich, Timo HFT Stuttgart
Pfeiffer, David Daimler AG
Franke, Uwe Daimler AG

This paper presents a stereo-vision based system for the recognition of dangerous situations at roundabouts. We investigate the necessary field of view and viewing direction using videos taken by a panoramic camera. The vision system is based on a well established disparity estimation scheme and the recently introduced medium-level representation called “Dynamic Stixel-World”. A time-to-contact measure that takes into account the fact that the car is approaching a roundabout is computed for driver warning systems or possible automated intervention. Our empirical studies reveal that the warning decision mimics to a human driver decisions well.

11:40-12:00 TuOR1S.2

The Analysis of the Acceleration of the Vehicle for Assessing the Condition of the Driver, pp. 571-576

Krotak, Tomas Univ. of West Bohemia
Simlova, Martina Univ. of West Bohemia

The article describes the analysis of the dynamic behaviour of a vehicle when driving, which indirectly reflects the behaviour of the driver. Our aim is to verify the options for assessing the condition of the driver that are provided by analysis of lateral and longitudinal acceleration of the vehicle. The steps taken, the types of metrics and their relevance for reliable acquisition of information about the medium-and short-term factors of the condition of the driver are described.

12:00-12:20 TuOR1S.3

Tracking and Classification of Arbitrary Objects with Bottom-Up/Top-Down Detection, pp. 577-582

Himmelsbach, Michael Univ. of the Bundeswehr, Munich
Wuensche, Hans Joachim Univ. Bw Munich

In the recent years, the introduction of dense, long-range 3D sensors has facilitated tracking of arbitrary objects. Especially in the context of autonomous driving, other traffic participants driving the streets usually stay well-segmented from each other. In contrast, pedestrians or bicyclists do not always stay on the road and they often get close to static structure of the environment, e.g. traffic lights or signs, bushes, parking cars etc. These objects are not as easy to segment, often resulting in an under-segmentation of the scene and wrong tracking results. This paper addresses the problem of tracking moving objects that are hard to segment from their static surroundings by utilizing top-down knowledge about the geometry of existing tracks during segmentation. This includes methods for discerning static from moving objects to reduce the rate of false positive tracks as well as a classification of tracks into pedestrian, bicyclist, motor bike, passenger car, van and truck classes by considering an objects appearance and motion history. The proposed tracking system is experimentally validated in challenging real-world inner-city traffic scenes.

12:20-12:40 TuOR1S.4

On-Road Position Estimation by Probabilistic Integration of Visual Cues, pp. 583-589

Popescu, Voichita Tech. Univ. of Cluj-Napoca
Danescu, Radu Gabriel Tech. Univ. of Cluj-Napoca
Nedevschi, Sergiu Tech. Univ. of Cluj-Napoca

This paper addresses the problem of finding the host vehicle's lateral position on a multi-lane road, using information obtained by processing video sequences. A very important cue for lane identification is the class of the boundaries of the current lane. This paper presents a reliable solution for lane boundary type identification, based on frequency analysis of the gray level profile of these boundaries, assuming that the current lane is already detected. The lane boundary information is combined with the obstacle information, through a Bayesian Network which will output, frame by frame, the probability of the vehicle to be positioned on each lane of the road. The probability result will be propagated throughout the sequence by a Particle Filter.

TuOR2S Room T1

Automated Vehicles and Collision Avoidance (Regular Session)

Chair: Stiller, Christoph Karlsruhe Inst. of Tech.

13:50-14:10 TuOR2S.1

Generation and Exploitation of Local Orthographic Imagery for Road Vehicle Localisation, pp. 590-596

Napier, Ashley Univ. of Oxford
Newman, Paul Univ. of Oxford

This paper is about road vehicle localisation based on vision using synthesised local orthographic imagery. We exploit state of the art stereo visual odometry (VO) on our survey vehicle to generate high precision synthetic orthographic images of the road surface as would be seen from overhead. The fidelity and detail of these images far exceeds that of aerial photographs. When undertaking subsequent passes of the same route, the vehicle is localised against the survey vehicle's trajectory by maximising the mutual information between the synthetic orthographic images and live image streams. Thus we explicitly leverage the gross appearance of the workspace rather than a discrete set of point features. We test our technique on data gathered from a road vehicle and show that centimeter- level precision is possible without the complexity and instability of contemporary feature based techniques.

14:10-14:30 TuOR2S.2

Planning Autonomous Vehicles in the Absence of Speed Lanes Using Lateral Potentials, pp. 597-602

Kala, Rahul Univ. of Reading
Warwick, Kevin Univ. of Reading

Chaotic traffic, prevalent in many countries, is marked by a large number of vehicles driving with different speeds without following any predefined speed lanes. Such traffic rules out using any planning algorithm for these vehicles which is based upon the maintenance of speed lanes and lane changes. The absence of speed lanes may imply more bandwidth and easier overtaking in cases where vehicles vary considerably in both their size and speed. Inspired by the performance of artificial potential fields in the planning of mobile robots, we propose here lateral potentials as measures to enable vehicles to decide about their lateral positions on the road. Each vehicle is subjected to a potential from obstacles and vehicles in front, road boundaries, obstacles and vehicles to the side and higher speed vehicles to the rear. All these potentials are lateral and only govern steering the vehicle. A speed control mechanism is also used for longitudinal control of vehicle. The proposed system is shown to perform well for obstacle avoidance, vehicle following and overtaking behaviors.

14:30-14:50 TuOR2S.3

Object-Related-Navigation for Mobile Robots, pp. 603-610

Mueller, Andre Univ. of the Bundeswehr Munich
Wuensche, Hans Joachim Univ. Bw Munich

Motivated by cognitive considerations about human knowledge representation we introduce a new approach for robot motion planning and control. Instead of reasoning about positions in a global cartesian coordinate frame we utilize relative orientation and distance information between perceived objects in the environment. A representation built upon these considerations enables on the one hand a tight coupling between perception, planning, and robot control, while on the other hand a means for precise robot control is established. But instead of describing a complete system we try to encourage for a new view in robotic planning problems by illustrating how the approach allows for plan generation and execution in a human comprehensible fashion by incorporating plans like: ”Overtake vehicle X on the right side, then follow lane Y.”

14:50-15:10 TuOR2S.4

Improving Information Dissemination in Sparse Vehicular Networks by Adding Satellite Communication, pp. 611-617

Spijker, Hanno Univ. of Twente

Kloiber, Bernhard	German Aerospace Center (DLR)
Strang, Thomas	German Aerospace Center (DLR)
Heijenk, Geert	Univ. of Twente

Information dissemination in pure Vehicular Ad Hoc NETworks (VANETs) such as ITS-G5 becomes problematic when the network is sparse. In situations where the number of vehicles who can act as a communication node is insufficiently low, e.g. in rural areas or during night-time, or because of a low market penetration of the technology in the early years of market introduction, certain range limits (unavailability of forwarding nodes) or timing limits (store-and-forward techniques) are stressed. Due to the limited communication range, VANETs start to build separated clusters, if the density of equipped vehicles is too low. Consequently, information dissemination without delay-massive store-and-forwarding is only possible within one cluster, but not beyond. This paper investigates the integration of Car2Car with an additional satellite communication technology. A realistic sparse vehicular network scenario has been simulated and evaluated with respect to the in-time reception of safety relevant information. The results show that information dissemination can be significantly improved through a limited number of vehicles or roadside-units which are additionally equipped with satellite terminals. In fact even the market introduction of VANET based ITS can be significantly accelerated with just a few vehicles equipped with non-VANET communication technology.

TuPO4S Room T1

Poster Session IV (Poster Session)

Chair: Yebes Torres, José Javier	Univ. of Alcalá

15:10-16:40 TuPO4S.1

Vision-Based Drowsiness Detector for Real Driving Conditions, pp. 618-623

García Daza, Iván	Univ. of Alcala
Bronte, Sebastian	Univ. de Alcalá
Bergasa, Luis M.	Univ. of Alcala
Almazán, Javier	Univ. of Alcalá
Yebes Torres, José Javier	Univ. of Alcalá

This paper presents a non-intrusive approach for drowsiness detection, based on computer vision. It is installed in a car and it is able to work under real operation conditions. An IR camera is placed in front of the driver, in the dashboard, in order to detect his face and obtain drowsiness clues from their eyes closure. It works in a robust and automatic way, without prior calibration. The presented system is composed of 3 stages. The first one is pre-processing, which includes face and eye detection and normalization. The second stage performs pupil position detection and characterization, combining it with an adaptive lighting filtering to make the system capable of dealing with outdoor illumination conditions. The final stage computes PERCLOS from eyes closure information. In order to evaluate this system, an outdoor database was generated, consisting of several experiments carried out during more than 25 driving hours. A study about the performance of this proposal, showing results from this testbench, is presented.

15:10-16:40 TuPO4S.2

Distributed Skip Air Index for Smart Broadcasting in Intelligent Transportation Systems, pp. 624-629

Maglaras, Leandros	Univ. of Thessaly
Katsaros, Dimitrios	Univ. of Thessaly

Wireless data broadcast received a lot of attention from industries and academia in recent years. In any form of a push-based broadcast, access latency and tuning time are vital issues, and in order to address the tradeoff among these competing goals, the broadcasting of indices along with the data is the most viable solution. Currently, two broad indexing families exist: those that exploit some form of a tree structure, and those that are based on some `distributed access on the air' mechanism. The latter family is the most popular and viable, because it allows for following `air-pointers' without the need to first find a tree root. The champion method of the distributed air index is the {it Exponential index} which however is not appropriate when the access pattern is skewed, i.e., some data items are more popular than the others. To address this shortcoming, we design a {it Distributed Skip Air Index} (disain), which exploits access statistics in order to improve average tuning time, while it preserves the access latency equal to that of the original Exponential index. To attest the superiority of the proposed indexing method, we perform a detailed simulation evaluation of the two competing methods.

15:10-16:40 TuPO4S.3

Real-Time Detection and Tracking of Pedestrians at Intersections Using a Network of Laserscanners, pp. 630-635

Meissner, Daniel Alexander	Univ. of Ulm
Reuter, Stephan	Univ. of Ulm
Dietmayer, Klaus	Univ. of Ulm

Accident analysis shows that the majority of accidents with body injuries occur in urban areas and more than 50 percent of those urban accidents happen at intersections. Due to that a major aim of the Ko-PER project, which is part of research initiative Ko-FAS, is to improve safety at intersections by infrastructure based perception. To recognize and track the moving objects, a network of laserscanner sensors observes the intersection and provides a 3D profile of the current scene. By means of the 3D measurements a robust and adaptive Gaussian mixture background model is trained to segment the measurements of dynamic objects and static objects. After the segmentation, the foreground points of each sensor are clustered based on the density of the point clouds and finally pedestrians are classified using dimension features. This paper focuses on tracking of pedestrians, which are the most vulnerable road users. In order to be able to integrate dependencies between the states of the pedestrians, a random finite set particle filter is used to track the pedestrians. The performance of the laserscanner based tracking system is shown and evaluated with measurements from the Ko-PER test intersection at Conti-Safety-Park. Therefore, the optimal subpattern assignment (OSPA) metric is used to evaluate the object recognition and tracking system.

15:10-16:40 TuPO4S.4

A Joint Integrated Probabilistic Data Association Filter for Pedestrian Tracking across Blind Regions Using Monocular Camera and Radar, pp. 636-641

Otto, Carola	Karlsruhe Inst. of Tech. Daimler AG
Gerber, Wladimir	Karlsruhe Inst. of Tech.
Puente León, Fernando	Karlsruhe Inst. of Tech.
Wirnitzer, Jan	Daimler AG

Pedestrian tracking in advanced driver assistance systems in commercial vehicles is not only important in the frontal field of perception, but also in the blind spot of the vehicle (right side), e.g., to mitigate or avoid collisions during turning maneuvers. While a camera system and radars observe the front, only a radar is available at the vehicle's side. This paper will present a Joint Integrated Probabilistic Data Association Filter, that tracks pedestrians in the frontal field of view and in the vehicle's blind spot. Although, the sensors do not have a common field of view, we show, that tracking across the blind region is advantageous, since information, that has already been retrieved by the front sensors can be conserved, and the confirmation time of the tracks could be reduced. The results include a comparison of the JIPDA approach running in real-time with an extended Kalman Filter with global nearest neighbor data association using data from real measurements. Furthermore, we will compare the fusion results to measurements of a 3D-Laser scanner. To the authors' knowledge, there is no JIPDAF approach for pedestrian tracking using camera HOG detections and radar sensors yet.

15:10-16:40 TuPO4S.5

Extrinsic Calibration of a Camera and a Lidar Based on Decoupling the Rotation from the Translation, pp. 642-648

Zhou, Lipu	Tsinghua Univ.
Deng, Zhidong	Tsinghua Univ.

In this paper, we propose a novel robust algorithm for the extrinsic calibration of a camera and a lidar. This algorithm utilizes checkerboard as a calibration object. Since the interaction between the estimation errors of the plane parameters obtained from checkerboard images downgrades the quality of extrinsic calibration results, a new geometric constraint is presented to decouple the rotation from the translation so as to reduce the effect of such an interaction. Weights that represent uncertainty of the unit normal vector to the checkerboard plane are introduced to totally evaluate the quality of each pair of image and lidar scan. Furthermore, we analyze the configuration of checkerboard pose and give a formula that is used to assess the configuration. We compare the proposed algorithm with the previous ones. Simulation and experimental results show that our algorithm is able to achieve more accurate extrinsic parameters than the existing algorithms. Meanwhile, we also design experiments to validate the effectiveness and efficiency of the presented weight and the assessment formula.

15:10-16:40 TuPO4S.6

Motion-Without-Structure: Real-Time Multipose Optimization for Accurate Visual Odometry, pp. 649-654

Lategahn, Henning	Inst. of Measurement & Control
Geiger, Andreas	Karlsruhe Inst. of Tech.
Kitt, Bernd	KIT
Stiller, Christoph	Karlsruhe Inst. of Tech.

State of the art visual odometry systems use bundle adjustment (BA) like methods to jointly optimize motion and scene structure. Fusing measurements from multiple time steps and optimizing an error criterion in a batch fashion seems to deliver the most accurate results. However, often the scene structure is of no interest and is a mere auxiliary quantity although it contributes heavily to the complexity of the problem. Herein we propose to use a recently developed incremental motion estimator which delivers relative pose displacements between each two frames within a sliding window inducing a pose graph. Moreover, we introduce a method to learn the uncertainty associated with each of the pose displacements. The pose graph is adjusted by non-linear least squares optimization while incorporating a motion model. Thereby we fuse measurements from multiple time steps much in the same sense as BA does. However, we obviate the need to estimate the scene structure yielding a very efficient estimator: Solving the non-linear least squares problem by a Gauss-Newton method takes approximately 1ms. We show the effectiveness of our method on simulated and real world data and demonstrate substantial improvements over incremental methods.

15:10-16:40 TuPO4S.7

Identification of Target Populations for Current Active Safety Systems Using Driver Behavior, pp. 655-660

Kusano, Kristofer	Virginia Tech.
Gabler, Hampton Clay	Virginia Tech.

Frontal Pre-Collision Systems (PCS) and Lane Departure Warning (LDW) systems are two of the first active safety systems to penetrate the passenger vehicle market. PCS can warn the driver, amplify the driver's braking effort, and autonomously brake even if there is no driver input. LDW systems deliver a warning to the driver when the vehicle is drifting out of its lane. The potential effectiveness of these two systems in the field not only depends on the crash scenarios they are likely to activate in but also on driver behavior. This study utilized the National Motor Vehicle Crash Causation Survey (NMVCCS), which unlike traditional databases focuses on behavioral aspects that lead to a collision. The target populations for PCS and LDW were found by aggregating crashes that had a) crash scenarios and b) critical reasons attributed to the collisions that were most likely mitigated by the systems. The warning component of PCS was found to be potentially effective in 45% of applicable crash scenarios. The brake assist and autonomous braking components were potentially effective in 71% and 74% of collisions, respectively. LDW was potentially effective in 18% of road departure collisions. These target populations are not estimates of actual system effectiveness but are quantification of the specific crash and driver scenarios most likely to be mitigated by LDW and PCS.

15:10-16:40 TuPO4S.8

Experts of Probabilistic Flow Subspaces for Robust Monocular Odometry in Urban Areas, pp. 661-667

Herdtweck, Christian	Max Planck Inst. for Biological Cybernetics
Curio, Cristobal	Max Planck Inst. for Biological Cybernetics

Visual odometry has been promoted as a fundamental component for intelligent vehicles. Relying solely on monocular image cues would be desirable. Nevertheless, this is a challenge especially in dynamically varying urban areas due to scale ambiguities, independent motions, and measurement noise. We propose to use probabilistic learning with auxiliar depth cues. Specifically, we developed an expert model that specializes monocular egomotion estimation units on typical scene structures, i.e. statistical variations of scene depth layouts. The framework adaptively selects the best fitting expert. For on-line estimation of egomotion, we adopted a probabilistic subspace flow estimation method. Learning in our framework consists of two components: 1) Partitioning of datasets of video + ground truth odometry data based on unsupervised clustering of dense stereo depth profiles and 2) training a cascade of subspace flow expert models. A probabilistic quality measure from the estimates of the experts provides a selection rule overall leading to improvements of egomotion estimation for long test sequences.

15:10-16:40 TuPO4S.9

Mono-Camera Based Pitch Rate Estimation in Nighttime Scenarios, pp. 668-673

Schüle, Florian	Daimler AG
Schweiger, Roland	Daimler AG
Dietmayer, Klaus	Univ. of Ulm
Hartmann, Oliver	Daimler AG

The camera relative pose is essential information for driver assistance systems in general, and especially so for systems that aim to visualize obstacles or other relevant objects for the driver. In order to display objects that were not detected in the vision frame of the camera (e.g. road information of a digital map), the exact transformation from camera to the world has to be known for every time frame. The horizontal movement of the camera in the real world is well known due to sufficiently accurate inertial sensors and wheel speed sensors available in the car. In contrast, the vertical movement is both unknown and highly dynamic. Relative pose estimation is a widely used technique that determines a vehicle's movement and rotation from frame to frame. These techniques rely primarily on point correspondences computed beforehand. In the nighttime case, these methods fail because of the poor image quality and low number of correspondences. This paper presents a method that fuses vehicle movement information with the features extracted from a mono camera. By restricting the problem to pitch estimation only, this method allows robust and accurate estimation of the vehicle's pitch movements even in nighttime scenarios. A highly accurate inertial navigation system is used to evaluate the results obtained in challenging real world nighttime video sequences. Experiments show the feasibility and robustness of the proposed approach.

15:10-16:40 TuPO4S.10

A New Collision Warning System for Lead Vehicles in Rear-End Collisions, pp. 674-679

Cabrera, Adrian	EPFL
Gowal, Sven	EPFL
Martinoli, Alcherio	EPFL

Collision warning systems (CWS) are safety sys- tems designed to warn the driver about an imminent collision. A CWS monitors the dynamic state of the traffic in real-time by processing information from various proprioceptive and exteroceptive sensors. It assesses the potential threat level and decides whether a warning should be issued to the driver through auditory and/or visual signals. Several measures have already been defined for threat assessment and various CWS have been proposed in literature. In this paper, we will focus on two time-based measures that assess both front and rear collision threats. In particular, a new threat metric, the time-to-last-second-acceleration T_{lsa}), for lead vehicles in rear-end collision is proposed and compared with its counterpart, the time-to-last-second-braking (T_{lsb}). The T_{lsa} is a novel time-based approach that focuses on the lead vehicle (as opposed to the following vehicle). It inherits the properties of the T_{lsb} and, as such, is coherent with the human judgement of urgency and severity of threats. It directly quantifies the threat level of the current dynamic situation before a required evasive action (i.e. maximum acceleration) needs to be applied. Furthermore, different warning thresholds are proposed by considering the average driver reaction time. Its effect on decreasing the severity of a rear-end collision is studied and its reliability is tested using a well-established physics-based robotics simulator, namely Webots.

15:10-16:40 TuPO4S.11

Multiple-Vehicle Longitudinal Collision Avoidance and Impact Mitigation by Active Brake Control, pp. 680-685

Lu, Xiao-Yun Univ. of California, Berkeley
Wang, Jianqiang Tsinghua Univ.

This paper proposes a control strategy for multiple-vehicle longitudinal collision avoidance or impact minimization if it is unavoidable. The system is defined as a coupled group of vehicles with vehicle-to-vehicle communication (V2V) in short enough distance following. The relationships with the further front and/or rear vehicle without V2V has been taken into account, which are modeled as lower bound limit on deceleration of the first vehicle and upper bound on maximum deceleration of the last vehicle in the system. The objective is to determine the desired deceleration for each vehicle such that the total impact of the system is minimized at each time step. The impact is defined as the relative kinetic energy between a pair of vehicles. The optimal control problem is further simplified as a finite time horizon predictive control (MPC), which is a quadratic programming problem. Simulation in Matlab shows some interesting results. The algorithm can be applied to vehicles with automated brake control capabilities with progressive market penetration of V2V.

15:10-16:40 TuPO4S.12

Lessons from a Minimal Middleware for IP-Based In-Car Communication, pp. 686-691

Weckemann, Kay BMW Group Res. and Tech.
Satzger, Florian August BMW Group Res. and Tech.
Stolz, Lothar BMW Group Res. and Tech.
Herrscher, Daniel BMW Group Res. and Tech.
Linnhoff-Popien, Claudia LMU Munich

Introducing the Internet Protocol to the in-car network, we need communication software for fast and robust development of future networked applications. The heterogeneity within the communication network concerning the differences in device capability and application requirements can be targeted by establishing a middleware consisting of several specifications. In this paper, we give evidence that a minimal middleware specification can be feasible even for smallest embedded Electronic Control Units but still largely interoperable with the more complex communication demands of powerful infotainment and driver assistance ones. We therefore present a prototype implementation, which is evaluated towards interoperability, resource consumption, and execution performance.

15:10-16:40 TuPO4S.13

360 Degree Multi Sensor Fusion for Static and Dynamic Obstacles, pp. 692-697

Schueler, Kai Tech. Univ. of Munich
Weiherer, Tobias TU München
Bouzouraa, Mohamed Essayed AUDI AG
Hofmann, Ulrich Audi AG Ingolstadt

In this paper an approach for 360 degree multi sensor fusion for static and dynamic obstacles is presented. The perception of static and dynamic obstacles is achieved by combining the advantages of model based object tracking and an occupancy map. For the model based object tracking a novel multi reference point tracking system, called best knowledge model, is introduced. The best knowledge model allows to track and describe objects with respect to a best suitable reference point. It is explained how the object tracking and the occupancy map closely interact and benefit from each other. Experimental results of the 360 degree multi sensor fusion system from an automotive test vehicle are shown.

15:10-16:40 TuPO4S.14

Free Space and Speed Humps Detection Using Lidar and Vision for Urban Autonomous Navigation, pp. 698-703

Fernandez Lopez, Carlos Univ. of Alcalá
Gavilán Velasco, Miguel Univ. of Alcala
Fernandez Llorca, David Univ. of Alcala
Quintero Mínguez, Raúl Univ. of Alcalá
Parra Alonso, Ignacio Univ. de Alcala
Vlacic, Ljubo Griffith Univ.
Sotelo, Miguel A. Univ. of Alcala
García Lorente, Alejandro Univ. of Alcalá

In this paper, a real-time free space detection system is presented using a medium-cost lidar sensor and a low cost camera. The extrinsic relationship between both sensors is obtained after an off-line calibration process. The lidar provides measurements corresponding to 4 horizontal layers with a vertical resolution of 3.2 degrees. These measurements are integrated in time according to the relative motion of the vehicle between consecutive laser scans. A special case is considered here for Spanish speed humps, since these are usually detected as an obstacle. In Spain, speed humps are directly related with raised zebra-crossings so they should have painted white stripes on them. Accordingly the conditions required to detect a speed hump are: detect a slope shape on the road and detect a zebra crossing at the same time. The first condition is evaluated using lidar sensor and the second one using the camera.

15:10-16:40 TuPO4S.15

A Track-To-Track Association Method for Automotive Perception Systems, pp. 704-710

Houenou, Adam Univ. of Tech. of Compiegne
Bonnifait, Philippe Univ. of Tech. of Compiegne
Cherfaoui, Véronique Univ. Tech. Compiègne
Boissou, Jean-François PSA Peugeot Citroën

Abstract--- Recent and future driver assistance systems use more and more sensors, that have individual tracking modules. For target tracking, it becomes necessary to find techniques to manage as simply as possible the use of a great number of independent and heterogeneous sensors, at the different stages of the process. This paper presents a modular high-level track-fusion architecture for a multisensor environment. This architecture allows the variation of the number and the types of the used sensors with no major change in the tracking algorithm. The paper also tackles the multisensor track-to-track association issue with a new algorithm based on a particular track-to-track distance computation. An example of target tracking method is shown to make use of the proposed architecture and the track-to-track association algorithm.

15:10-16:40 TuPO4S.16

COL: A Data Collection Protocol for VANET, pp. 711-716

Dieudonne, Yoann Univ. de Picardie Jules Vernes
Ducourthial, Bertrand Univ. de Tech. de Compiègne (UTC)
Senouci, Sidi-Mohammed Univ. de Bourgogne

In this paper, we present a protocol to collect data within a vehicular ad hoc network (VANET). In spite of the intrinsic dynamic of such network, our protocol simultaneously offers three relevant properties: (1) It allows any vehicle to collect data beyond its direct neighborhood (i.e., vehicles within direct communication range) using vehicle-to-vehicle communications only (i.e., the infrastructure is not required); (2) It tolerates possible network partitions; (3) It works on demand and stops when the data collection is achieved. To the best of our knowledge, this is the first collect protocol having these three characteristics.

All that is chiefly obtained thanks to a specific tool, namely Operator ant, borrowed from the self-stabilization area which confers to our algorithm the nice property to recover by itself from topology changes. In addition to a theoretical proof of correctness, our protocol has been implemented and tested through the Airplug Software Distribution: Road and lab experiments are presented and discussed.

15:10-16:40 TuPO4S.17

Real-Time Dynamic Environment Perception in Driving Scenarios Using Difference Fronts, pp. 717-722

Vatavu, Andrei Tech. Univ. of Cluj-Napoca
Danescu, Radu Gabriel Tech. Univ. of Cluj-Napoca
Nedevschi, Sergiu Tech. Univ. of Cluj-Napoca

The environment representation is one of the main challenges of autonomous navigation. In the case of complex driving environments such as crowded city traffic scenarios, achieving satisfactory results becomes even more difficult. In this paper we propose a real-time solution for two main issues of advanced driver assistance systems: unstructured environment representation and extraction of dynamic properties of traffic participants. For the real-time environment representation we propose a solution to extract object delimiters from the traffic scenes and represent them as polygonal models. In order to track dynamic entities, an intermediate evidence map named “Stereo Temporal Difference Map” is proposed. This difference map is computed by comparing the occupancy of a cell between two consecutive frames. Based on the Stereo Temporal Difference Map information, difference fronts are extracted and are subjected to a particle based filtering mechanism. Finally, the provided dynamic features are associated to the extracted polygonal models. The result is a more compact representation of the dynamic environment.

15:10-16:40 TuPO4S.18

Autonomous Driving for Vehicular Networks with Nonlinear Dynamics, pp. 723-729

Iftekhar, Lamia — Dartmouth Coll.

Olfati-Saber, Reza — Dartmouth Coll.

In this paper, we introduce cooperative autonomous driving algorithms for vehicular networks with nonlinear mobile robot dynamics in urban environments that take human safety into account and are capable of performing vehicle-to-vehicle (V2V) and vehicle-to-pedestrian (V2P) collision avoidance. We argue that "flocks" are multi-agent models of vehicular traffic on roads and propose novel autonomous driving architectures and algorithms for cyber-physical vehicles capable of performing autonomous driving tasks such as lane-driving, lane-changing, braking, passing, and making turns. Our proposed autonomous driving algorithms are inspired by Olfati-Saber's flocking theory. Though, there are notable differences between autonomous driving on urban roads and flocking behavior---flocks have a single desired destination whereas most drivers on road do not share the same destination. We refer to this collective behavior (driving) as "multi-objective flocking." The self-driving vehicles in our framework turn out to be hybrid systems with a finite number of discrete states that are related to the driving modes of vehicles. Complex driving maneuvers can be performed using a sequence of mode switchings. We use near-identity nonlinear transformations to extend the application of particle-based autonomous driving algorithms to multi-robot networks with nonlinear dynamics. The derivation of the mode switching conditions that preserve safety is non-trivial and an important part of the design of autonomous driving algorithms. We present several examples of driving tasks that can be effectively performed using our proposed driving algorithms.

15:10-16:40 TuPO4S.19

Probe Vehicle Data for Characterizing Road Conditions Associated with Inclement Weather to Improve Road Maintenance Decisions, pp. 730-735

Hainen, Alexander — Purdue Univ.

Remias, Stephen — Purdue Univ.

Brennan, Thomas — Purdue Univ.

Day, Christopher — Purdue Univ.

Bullock, Darcy — Purdue Univ.

Connected vehicle concepts can provide an enormously rich new data source that can be used for a variety of safety and performance measure applications. However, to date there are very limited connected vehicle deployments or applications other than graphical color coded maps provided by private sector companies. This paper takes an approach of introducing the concept of tabulating statistical distributions of highway segment space-mean speed to characterize roadway conditions associated with inclement weather. These statistics are computed for segments that correspond to a particular winter weather highway maintenance route. Several examples are presented that illustrates how these statistics can be used to identify the onset of hazardous winter weather and provide outcome oriented performance measure for the roadway condition. During one of the winter storms analyzed, the space mean speed decreased approximately 20mph during a storm and the interquartile range, increased from about 8mph to about 12mph. The paper concludes with a table that summarizes the number of hours, by day, that each snow and ice maintenance route had space mean speeds below 45mph. Using such statistics, geographic influences and alternative strategies for winter operations can be quantitatively assessed to determine the best practices for maintaining high travel time reliability during inclement weather conditions.

15:10-16:40 TuPO4S.20

Stereo Based Visual Odometry in Difficult Traffic Scenes, pp. 736-741

Golban, Catalin — Tech. Unversity of Cluj-Napoca

Szakats, Istvan — Tech. Univ. Cluj Napoca

Nedevschi, Sergiu — Tech. Univ. of Cluj-Napoca

Reliable vehicle ego motion estimation based on visual information is an important research goal because it has applications like accurate long term localization by fusion with other sensors, temporal fusion between frames, moving obstacles detection and tracking, path planning etc. This paper evaluates and significantly improves some steps of existing visual odometry methods. The main contribution is related to accuracy improvements in case of illumination changes by using the rank transform. Additionally we propose a new consistency check, based on image deformations, for subsets of features considered during the RANSAC iterations of the algorithm. Performance of GPU execution and results in various traffic scenarios are presented in order to show the advantages and the robustness of the method.

15:10-16:40 TuPO4S.21

Illumination Invariance for Driving Scene Optical Flow Using Comparagram Preselection, pp. 742-747

Dederscheck, David — Goethe Univ. Frankfurt

Mueller, Thomas — Goethe-Univ. Frankfurt am Main

Mester, Rudolf — Univ. Frankfurt

In the recent years, advanced video sensors have become common in driver assistance, coping with the highly dynamic lighting conditions by nonlinear exposure adjustments. However, many computer vision algorithms are still highly sensitive to the resulting sudden brightness changes. We present a method that is able to estimate the relative intensity transfer function (RITF) between images in a sequence even for moving cameras. The according compensation of the input images can improve the performance of further vision tasks significantly, here demonstrated by results from optical flow. Our method identifies corresponding intensity values from areas in the images where no apparent motion is present. The RITF is then estimated from that data and regularized based on its curvature. Finally, built-in tests reliably flag image pairs with ‘adverse conditions' where no compensation could be performed.

15:10-16:40 TuPO4S.22

Visible Light Communications in Intelligent Transportation Systems, pp. 748-753

Kumar, Navin — Inst. of Telecommunication, Univ. of Aveiro, Portugal

Lourenço, Nuno — Inst. de Telecomunicações

Terra, Domingos — Inst. de Telecomunicações - Aveiro

Alves, Luis Nero — IT / Univ. de Aveiro

Aguiar, Rui L — Inst. de Telecomunicações, Univ. de Aveiro

Emerging intelligent transportation systems (ITS) are based on several technologies. A new concept of integrating visible light communications (VLC) in ITS is introduced in this paper.VLC in ITS is a cost effective method of implementation. This paper presents a VLC broadcast system considering LED-based traffic lights. It discusses the integration of traffic light road side unit (RSUs) within the existing ITS architecture. A prototype demonstrator of the designed VLC systems is also presented. A robust modulation technique based on direct sequence spread spectrum (DSSS) sequence inverse keying (SIK) has been implemented to minimize the effect of noise sources. Experimental results show data communication range of over 40m with 200mm custom designed traffic light, even during bright sun light.

15:10-16:40 TuPO4S.23

Robust Extraction of Lane Markings Using Gradient Angle Histograms and Directional Signed Edges, pp. 754-759

Satzoda, Ravi Kumar	Nanyang Tech. Univ.
Sathyanarayana, Suchitra	Nanyang Tech. Univ.
Thambipillai, Srikanthan	Nanyang Tech. Univ.

In this paper, we propose novel block-based techniques for robust extraction of lane marking edges in complex scenarios, such as in the presence of shadows, vehicles, other road markings etc. The techniques are based on the properties of lane markings and involve a two-stage processing: (1) generation of customized edge maps using histograms of gradient angles, and (2) directional signed edges in combination with Hough Transform to identify lane markings. It is shown that the proposed techniques show a detection accuracy of as high as 98% on test data collected on real road scenarios, representing the various complex cases.

15:10-16:40 TuPO4S.24

Obstacle Detection Using Sparse Stereovision and Clustering Techniques, pp. 760-765

Kramm, Sebastien	INSA Rouen
Bensrhair, Abdelaziz	INSA de Rouen

We present a novel technique for localisation of scene elements through sparse stereovision, targeted at obstacle detection. Applications are autonomous driving or robotics. Given a sparse 3D map computed from low-cost features and % extraction algo and matching with many matching errors, we present a technique that can achieve localisation in a real-time context of all potential obstacles in front of the camera pair. We use v-disparity histograms for identifying relevant depth values, and extract from the 3D map successive subsets of points that correspond to these depth values. We apply a clustering step that provides the corresponding elements localisation. These clusters are then used to build a set of potential obstacles, considered as high level primitives. Experimental results on real images are provided.

15:10-16:40 TuPO4S.25

Vehicle Detection Using Discriminatively Trained Part Templates with Variable Size, pp. 766-771

Tehrani Nik Nejad, Hossein	DENSO Corp.
Kawano, Taiki	Toyota Tech. Inst.
Mita, Seiichi	Toyota Tech. Inst.
Shimizu, Mikio	DENSO Corp.

Introduction of new local and semi-local features has played an important role in advancing the performance of object recognitions. Deformable part models prepare elegant framework for representing object categories and both efficient and accurate, achieving state-of the-art results. In this paper, We consider the problem of training a part-based model with variable size from images labeled only with bounding boxes around the objects. We consider part size as a latent variable and try to optimize simultaneously size and place of part templates to cover high-energy regions of the object. Extensive experiments in urban scenarios for vehicle detection show that the average precision of deformable part model significantly is improved from 72.10% to 82.41% without losing the average recall.

15:10-16:40 TuPO4S.26

Multirate Active Steering Control for Autonomous Vehicle Lateral Maneuvering, pp. 772-777

Lee, Seung-Hi	Hanyang Univ.
Lee, Young Ok	Hanyang Univ.
Son, YoungSeop	Mando
Chung, Chung Choo	Hanyang Univ.

A multirate steering control scheme is developed for autonomous vehicle lateral maneuvering. The proposed scheme consists of a multirate extended Kalman filter and a state feedback control. The multirate extended Kalman filter is to estimate the vehicle states at a fast rate of the car ECU using multirate sensing - a slow vision-based lane detection by a camera and fast motion detection by inertia sensors. A method to design the multirate decentralized extended Kalman filter is presented. Through application results, the proposed multirate steering control scheme is shown to exhibit significantly improved control performance.

15:10-16:40 TuPO4S.27

Drivable Space Characterization Using Automotive Lidar and Georeferenced Map Information, pp. 778-783

Moras, Julien	Heudiasyc UMR 6599 Univ. de Tech. de Compiègne
Rodriguez Florez, Sergio Alberto	Univ. Paris Sud. Inst. d'Electronique Fondamentale UMR 8
Drevelle, Vincent	Univ. of Tech. of Compiegne
Dherbomez, Gerald	CNRS HEUDIASYC
Cherfaoui, Véronique	Univ. Tech. Compiègne
Bonnifait, Philippe	Univ. of Tech. of Compiegne

The characterization in real-time of the drivable space in front of the vehicle is a key issue for safe autonomous navigation or driving assistance. This paper presents a method that uses a lidar (a multilayer laser scanner) integrated in the front bumper of an automotive vehicle. A grid processing is first applied to detect and localize objects in the immediate environment after having compensated the movement of the vehicle. Accurate map information is then introduced in the perception scheme to refine the characterization of the drivable space. The paper details the different processing stages necessary to implement this method and presents the design of the system that has been prototyped on board an experimental vehicle. We report real experiments carried out in challenging urban environments to illustrate the performance of this approach which has been evaluated thanks to a precise retro-projection of the estimated drivable space in a wide-angle scene camera.

WePO5S Room T1

Poster Session V (Poster Session)

Chair: Maldonado-Bascón, Saturnino	Univ. de Alcalá

09:50-11:20 WePO5S.1

Multipath Mitigation in GNSS-Based Localization Using Robust Optimization, pp. 784-789

Sünderhauf, Niko	Chemnitz Univ. of Tech.
Obst, Marcus	Chemnitz Univ. of Tech.
Protzel, Peter	Chemnitz Univ. of Tech.
Wanielik, Gerd	Chemnitz Univ. of Tech.

Our paper adapts recent advances in the SLAM (Simultaneous Localization and Mapping) literature to the problem of multipath mitigation and proposes a novel approach to successfully localize a vehicle despite a significant number of multipath observations. We show that GNSS-based localization problems can be modelled as factor graphs and solved using efficient nonlinear least squares methods that exploit the sparsity inherent in the problem formulation. Using a recently developed novel approach for robust optimization, satellite observations that are subject to multipath errors can be successfully identified and rejected during the optimization process. We demonstrate the feasibility of the proposed approach on a real-world urban dataset and compare it to an existing method of multipath detection.

09:50-11:20 WePO5S.2

Improving Moving Objects Tracking Using Road Model for Laser Data, pp. 790-795

Baig, Qadeer	UJF
Aycard, Olivier	Univ. Grenoble1

In this paper we have presented a fast algorithm to detect road borders from laser data. Two local search windows, one on right side of the host vehicle and the other on left, are moved right and left respectively from the current position of vehicle in map. A score function is evaluated to know the presence or absence of the road border in current search window. We have used the detected road border information to reduce false alarms in our previous work on DATMO (detection and tracking of moving objects). We also show how these information can be used to infer drivable area and the presence of intersections on the road. Results on data sets obtained from real demonstrator vehicles show that this technique can be successfully applied in real time.

09:50-11:20	WePO5S.3

Detection & Classification of Arrow Markings on Roads Using Signed Edge Signatures, pp. 796-801

Sathyanarayana, Suchitra	Nanyang Tech. Univ.
Satzoda, Ravi Kumar	Nanyang Tech. Univ.
Thambipillai, Srikanthan	Nanyang Tech. Univ.

In this paper, we propose a novel method to robustly identify and classify arrow markings in road images. In the proposed method, simple and unique signatures are first derived for the various arrow types, based on signed edge maps and decomposing the arrows into smaller parts. The signed edge maps are processed using Hough Transform (HT), and the resulting Hough spaces are analyzed systematically, using a set of simple rules. The signatures are rotation-invariant and scale-invariant, thereby making the approach robust to variations in the appearance of the arrow markings. It is shown that the method yields a high detection and classification accuracy, of as high as 97% in the test images considered.

09:50-11:20	WePO5S.4

Detection, Classification and Tracking of Moving Objects in a 3D Environment, pp. 802-807

Azim, Asma	Univ. of Grenoble I
Aycard, Olivier	Univ. Grenoble1

In this paper, we present a framework based on 3D range data to solve the problem of simultaneous localization and mapping (SLAM) with detection and tracking of moving objects (DATMO) in dynamic environments. The basic idea is to use an octree based Occupancy Grid representation to model dynamic environment surrounding the vehicle and to detect moving objects based on inconsistencies between scans. The proposed method for the discrimination between moving and stationary objects without a priori knowledge of the targets is the main contribution of this paper. Moreover, the detected moving objects are classified and tracked using Global Nearest Neighbor (GNN) technique. The proposed method can be used in conjunction with any type of range sensors however we have demonstrated it using the data acquired from a Velodyne HDL-64E LIDAR sensor. The merit of our approach is that it allows for an efficient three dimensional representation of a dynamic environment, keeping in view the enormous amount of information provided by 3D range sensors.

09:50-11:20	WePO5S.5

A Platform for the Development and Evaluation of Passive Safety Applications, pp. 808-813

Szczurek, Piotr	Univ. of Illinois at Chicago
Xu, Bo	Univ. of Illinois at Chicago
Wolfson, Ouri	Univ. of Illinois at Chicago
Lin, Jie (Jane)	Univ. of Illinois at Chicago

In this paper, we present a platform for aiding in the development and evaluation of novel ITS passive safety applications. Such applications work by having vehicles detect certain events that may be dangerous to other vehicles and disseminating reports about these events using wireless communication. A vehicle receiving the report about the event can then be warned. However, a large number of false warnings will lead to driver desensitization, which will reduce the safety benefit. To overcome this issue, a relevance estimator that will determine for which reports a warning will be given has to be devised for each new application. Our platform allows for an easy, fast method of developing these estimators and evaluating them in simulations. We demonstrated the feasibility of this approach with three example applications.

09:50-11:20	WePO5S.6

Co-Training of Context Models for Real-Time Vehicle Detection, pp. 814-820

Gepperth, Alexander	Ec. National Superieure de Tech. Avancées

We describe a simple way to reduce the amount of required training data in context-based models of real-time object detection. We demonstrate the feasibility of our approach in a very challenging vehicle detection scenario comprising multiple weather, environment and light conditions such as rain, snow and darkness (night).

The investigation is based on a real-time detection system effectively composed of two trainable components: an exhaustive multiscale object detector ("signal-driven detection"), as well as a module for generating object-specific visual attention ("context models") controlling the signal-driven detection process. Both parts of the system require a significant amount of ground-truth data which need to be generated by human annotation in a time-consuming and costly process.

Assuming sufficient training examples for signal-based detection, we demonstrate that a co-training step can eliminate the need for separate ground-truth data to train context models. This is achieved by directly training context models with the results of signal-driven detection. We show that this process is feasible for different qualities of signal-driven detection, and maintains the performance gains from context models.

As it is by now widely accepted that signal-driven object detection can be significantly improved by context models, our method allows to train strongly improved detection systems without additional labor, and above all, cost.

09:50-11:20	WePO5S.7

Lateral Stability Analysis of On-Road Vehicles Using Lyapunov's Direct Method, pp. 821-826

Sadri, Sobhan	The Univ. of Manitoba
Wu, Christine Qiong	Univ. of Manitoba

Vehicle rollover may occur due to the yaw instability. Hence, the yaw stability analysis can help improve vehicle safety. In this paper, Lyapunov's direct method is applied to the lateral stability analysis of the non-linear vehicle model driven in a straight-line with constant longitudinal velocity, where the non-linearity of the model comes from the non-linear expression of the lateral tire forces. Two new Lyapunov functions are proposed. These functions do not explicitly depend on vehicle parameters and estimate the larger stability regions as compared with previous works.

09:50-11:20	WePO5S.8

Leaks Detection and Characterization in Diesel Air Path Using Levenberg-Marquardt Neural Networks, pp. 827-832

Benkaci, Mourad	IRSEEM-ESIGELEC
Hoblos, Ghaleb	IRSEEM/ESIGELEC
Bencherif, Karim	RENAULT

Fault detection and isolation are one of the most important steps in automotive diagnosis. In this work, a new OBD scheme is proposed dealing with fault detection and localization problem in diesel engine. Especially, the leak detection and characterization problem in diesel air path is studied. The proposed solution is based on the neural network trained using Levenberg-Marquardt algorithm in order to model the engine dynamics. This model is used to detect and characterize any leak occurred in intake part of the air path. The model is learned and validated using data generated by xMOD. This tool is used again for test. The effectiveness of proposed approach is illustrated in simulation when the system run on a low speed, a low load and the considered leak affecting the air path is very small.

09:50-11:20	WePO5S.9

Validation of Reference Laboratories to Place in Service Railway Projects (Tracks and Trains), pp. 833-836

Tamarit, Jaime	CEDEX / LIF
Bueno, Jose	CEDEX / LIF
Molina, Daniel	CEDEX / LIF

The Railway Interoperability Laboratory of CEDEX contributes to the process of placing Railway projects into service using reference tools loaded with project data and with real equipment connected. This strategy provides a more efficient and controlled environment, assures the interoperability of the project and facilitates the integration track/ train. The validation of the Laboratory by comparing track and laboratory records makes acceptable the laboratory tests for the safety departments of the Infrastructure Managers and Operators. This communication provides an overview of the process of the laboratory validation.

09:50-11:20	WePO5S.10

Empirical IEEE 802.11p Performances Evaluation on Test Tracks, pp. 837-842

Demmel, Sébastien	QUT & IFSTTAR
Lambert, Alain	IFSTTAR
Gruyer, Dominique	IFSTTAR
Rakotonirainy, Andry	Queensland Univ. of Tech.
Monacelli, Eric	Univ. de Versailles Saint-Quentin-en-Yvelines

IEEE 802.11p is the new standard for inter-vehicular communications (IVC) using the 5.9 GHz frequency band; it is planned to be widely deployed to enable cooperative systems. 802.11p uses and performances have been studied theoretically and in simulations over the past years. Unfortunately, most of these results have not been confirmed by on-tracks experimentation.In this paper, we describe field trials of 802.11p technology with our test vehicles. Criteria such as maximum range, latency and frame loss are examined.

09:50-11:20	WePO5S.11

3-Layer Fault Tolerance Strategy in 6x6 Hybrid Electric Vehicle Which Has Independent Steering and In-Wheel Drives, pp. 843-848

Chae, Heeseo	Samsung Tech.
Nah, Jaewon	Seoul National Univ.
Hong, Ji Tae	Samsung Tech.
Lee, Dae Ok	Agency for Defense Development

The hierarchy design to overcome the vehicle's fault will be introduced. It is consists of three layers such as physical, presentation, and application layer. Fault detection and physical redundant mechanism is the main issue of the physical layer. Creating fault code and finding out the maximum fault level among multiple fault codes are important activities in the presentation layer. The driving method by remaining motors and emergency stop are vehicle level's action based on vehicle dynamic algorithm and control sequence of the application layer. After explaining each layer's role and activities in detail, the result of the experiments are shown to verify its completeness and superiority.

09:50-11:20	WePO5S.12

Semiotic Prediction of Driving Behavior Using Unsupervised Double Articulation Analyzer, pp. 849-854

Taniguchi, Tadahiro	Ritsumeikan Univ.
Nagasaka, Shogo	Ritsumeikan Univ.
Hitomi, Kentarou	Toyota InfoTechnology Center Co.,Ltd.
Naiwala P., Chandrasiri	Toyota InfoTechnology Center
Bando, Takashi	DENSO Corp.

In this paper, we propose a novel semiotic prediction method for driving behavior based on double articulation structure. It has been reported that predicting driving behavior from its multivariate time series behavior data by using machine learning methods, e.g., hybrid dynamical system, hidden Markov model and Gaussian mixture model, is difficult because a driver's behavior is affected by various contextual information. To overcome this problem, we assume that contextual information has a double articulation structure and develop a novel semiotic prediction method by extending nonparametric Bayesian unsupervised morphological analyzer. Effectiveness of our prediction method was evaluated using synthetic data and real driving data. In these experiments, the proposed method achieved long-term prediction 2-6 times longer than some conventional methods.

09:50-11:20	WePO5S.13

Vehicle Detection and Tracking Using Mean Shift Segmentation on Semi-Dense Disparity Maps, pp. 855-860

Lefebvre, Sébastien	IFSTTAR
Ambellouis, Sebastien	Inst. of Res.

This paper describes an original joint obstacle detection and tracking method based on a Mean Shift algorithm and semi-dense disparity maps. The semi-dense disparity maps are computed with a local 1D fuzzy scanline stereo matching approach. Each map is associated to a confidence map that is used to remove bad matches. The Mean Shift algorithm is applied to simultaneously extract each vehicle and track the 3D points belonging to the same vehicle along the sequence. We show that several vehicles can be efficiently detected and that a semi-dense disparity map is sufficient to reach an accurate segmentation even when occlusions occur. This paper presents some results on real image sequences acquired in the context of Advanced Driver Assistance Systems.

09:50-11:20	WePO5S.14

Cooperative Driving in Mixed Traffic Networks – Optimizing for Performance, pp. 861-866

Calvert, Simeon Craig	TNO
Van den Broek, Thijs Hendrikus Adrianus	TNO
van Noort, Martijn	TNO

This paper discusses a cooperative adaptive cruise control application and its effects on the traffic system. In previous work this application has been tested on the road, and traffic simulation has been used to scale up the results of the field test to larger networks and more vehicles. The present study investigates the dependence of the traffic impact of the time headway settings of the application and on its penetration rate. It will be shown both theoretically and empirically that traffic flows and road capacities will improve significantly with the fraction of equipped vehicles, and that this improvement depends on the configuration of the application.

09:50-11:20	WePO5S.15

Satellite Image Based Topological Map Building Method for Intelligent Mobile Robots, pp. 867-872

Lee, Yu-Cheol	ETRI
Christiand, Christiand	Department of Robot Cognition and System, ETRI
Yu, Wonpil	ETRI
Kim, Sunghoon	ETRI

This paper presents an efficient method for building a topological map for robots in urban environments based on satellite image maps acquired from a geographic information system (GIS). In urban space, mobile robots need a special map, such as a topological map, to generate a path toward their goal. A topological map for mobile robot navigation should include semantic data, e.g., the width and type of road. We divide the satellite image based topological map building process into two steps. The first step is defining the topological map model to fit the mobile robot navigation in an urban environment. The second step is generating a topological map from existing satellite image maps downloaded from the GIS to reduce the cost and improve the accuracy in building the map. If a GIS-based topological map is constructed once, it is possible to use the map for the navigation of various robots as common spatial data. To validate the proposed mapping method, we show details of its implementation in map building as well as in a navigation experiment in real outdoor environments, such as a campus or city district.

09:50-11:20	WePO5S.16

Adaptive Visual Memory for Mobile Robot Navigation in Dynamic Environment, pp. 873-878

Courbon, Jonathan	Inst. Pascal
Mezouar, Youcef	LASMEA
Korrapati, Hemanth	Inst. Pascal

A central clue for implementation of visual memory based navigation strategies relies on efficient point matching between the current image and the key images of the memory. However, the visual memory may become out of date after some times because the appearance of real-world environments keeps changing. It is thus necessary to remove obsolete information and to add new data to the visual memory over time. In this paper, we propose a method based on short-term and long term memory concepts to update the visual memory of mobile robots during navigation. The results of our experiments show that using this method improves the robustness of the localization and path-following steps.

09:50-11:20	WePO5S.17

Effectiveness Study of Cooperative Sensor Systems for VRU-Safety, pp. 879-884

Kloeden, Horst	BMW Group Res. and Tech.
Schwarz, Daniel	BMW Group
Biebl, Erwin	Tech. Univ. München
Rasshofer, Ralph	BMW Forschung und Tech. GmbH

The performance of environment perception sensors plays an important roll for the effectiveness of advanced driver assistance systems (ADAS). This paper analyzes different methods for sensor model generation for effectiveness simulations and derives a new sensor model unifying the main advantages of common deterministic and stochastic approaches. As an example, the paper utilizes the new sensor model to investigate the benefits of cooperative sensor systems for pedestrian safety. cooperative sensors are a relatively new technology which allows for unique object classification and localization regardless of a sight obstruction. To generate a model, real world measurements are collected with a cooperative sensor system operating at 2.4 GHz. Finally, effectiveness simulations are performed to analyze the benefit of cooperative sensor systems in comparison to a single sensor system based on a monocular camera and a high-end fusion system with respect to a set of pedestrian accidents.

09:50-11:20	WePO5S.18

Learning Lane Change Trajectories from On-Road Driving Data, pp. 885-890

Yao, Wen	Peking Univ.
Zhao, Huijing	Peking Univ.
Davoine, Franck	CNRS LIAMA Sino French Lab.
Zha, Hongbin	Peking Univ.

Lane change is one of the most principle driving behaviors on structure roads. It frequently happens in daily driving. A key issue in lane change technique is trajectory planning, where a set of trajectories describing possible vehicle motions are generated by applying a parametric function, and by uniformly sampling the end states in configuration space; the trajectories are then examined to find an optimal one for execution. However, such a trajectory set has poor efficiency due to the large sample number. Many trajectories in this set seldom happen in real human driving behaviors. In this research, lane change trajectories are collected from real driving data of different drivers. Their statistics are analyzed, through which, a simplified trajectory set is generated. Experiment results show that the trajectory set has much less number of samples but can still guarantee to cover usual lane change behaviors of human being.

09:50-11:20	WePO5S.19

Google Street View Images Support the Development of Vision-Based Driver Assistance Systems, pp. 891-895

Salmen, Jan	Ruhr-Univ. Bochum
Houben, Sebastian	Ruhruniversität Bochum
Schlipsing, Marc	Ruhr-Univ. Bochum

For the development of vision-based driver assistance systems, large amounts of data are needed, e.g., for training machine learning approaches, tuning parameters, and comparing different methods. There are basically three possible ways to obtain the required data: using freely available benchmark sets, doing own recordings, or falling back to synthesized sequences. In this paper, we show that Google Street View can be incorporated as a valuable source for image data. Street View is the largest publicly available collection of images recorded from a drivers' perspective, covering many different countries and scenarios. We describe how to efficiently access the data and present a framework that allows for virtual driving through a network of images. We assess its performance and show its applicability in practice considering traffic sign recognition as an example. The introduced approach supports an efficient collection of image data relevant to training and evaluating machine vision modules. It is easily adaptable and extendible, whereby Street View becomes a valuable tool for developers of vision-based assistance systems.

09:50-11:20	WePO5S.20

Optimal Experts' Knowledge Selection for Intelligent Driving Risk Detection Systems, pp. 896-901

Martín de Diego, Isaac	Univ. Rey Juan Carlos
S. Siordia, Oscar	Univ. Rey Juan Carlos
Conde, Cristina	Univ. Rey Juan Carlos
Cabello, Enrique	Univ. Rey Juan Carlos

This paper presents a method for the selection of the optimal combination of experts' knowledge needed for the generation of a reliable driving risk ground truth. The driving risk of a controlled driving session, recorded in a highly realistic truck simulator, was evaluated by a large number of traffic safety experts. The risk evaluations were grouped in several clusters in order to find experts with high agreement. Next, a method for the selection of the optimal experts' evaluations is proposed. We found, through the experiments performed in this study, that a low number of experts are sufficient for the properly detection of driving risks. In addition, we show some of the advantages of the consideration of traffic safety experts' knowledge for the generation of a driving risk ground truth.

09:50-11:20	WePO5S.21

Smart City for VANETs Using Warning Messages, Traffic Statistics and Intelligent Traffic Lights, pp. 902-907

Tripp Barba, Carolina	Univ. Pol. de Catalunya (UPC)
Mateos, Miguel Ángel	Univ. Pol. de Catalunya (UPC)
Regañas Soto, Pablo	Univ. Pol. de Catalunya (UPC)
Mezher, Ahmad Mohamad	Univ. Pol. de Catalunya (UPC)
Aguilar Igartua, Mónica	Univ. Pol. de Catalunya (UPC)

Road safety has become a main issue for governments and car manufacturers in the last twenty years. The development of new vehicular technologies has favoured companies, researchers and institutions to focus their efforts on improving road safety. During the last decades, the evolution of wireless technologies has allowed researchers to design communication systems where vehicles participate in the communication networks. Thus, new types of networks, such as Vehicular Ad Hoc Networks (VANETs), have been created to facilitate communication between vehicles themselves and between vehicles and infrastructure. New concepts where vehicular networks play an important role have appeared the last years, such as smart cities and living labs. Smart cities include intelligent traffic management in which data from the TIC (Traffic Information Centre) infrastructures could be reachable at any point. To test the possibilities of these future cities, living labs (cities in which new designed systems can be tested in real conditions) have been created all over Europe. The goal of our framework is to transmit information about the traffic conditions to help the driver (or the vehicle itself) take adequate decisions. In this work, the development of a warning system composed of Intelligent Traffic Lights (ITLs) that provides information to drivers about traffic density and weather conditions in the streets of a city is proposed and evaluated through simulations.

09:50-11:20	WePO5S.22

An Optimization Model for Microscopic Centralized Traffic Management of Intelligent Vehicles in a Segment of a Single Lane Highway, pp. 908-913

Reghelin, Ricardo	Univ. Tecnológica Federal do Paraná
Arruda, Lúcia Valéria Ramos	Univ. Tecnológica Federal do Paraná (UTFPR)

This paper presents a mathematical solution to optimize the microscopic centralized traffic management of intelligent vehicles in a single lane highway. Therefore an optimization model that uses the travel time as criteria is proposed. The model considers important elements of a highway system such as capacity of acceleration of each vehicle, traffic rules and topography of the lane. It deals with traffic situations such as overtaking, slopes, obstacles, and speed reducers. As the model takes time to run, a simulation algorithm is also proposed. The results of the algorithm provide also references to solve the problem of overtaking priority. Moreover, new indexes for microscopic traffic assessment are proposed. Test results are presented to evaluate both the model and the algorithm.

09:50-11:20	WePO5S.23

Monitoring and Predicting Charging Behaviour for Electric Vehicles, pp. 914-919

Hill, Graeme	NEWCASTLE Univ.
Blythe, Phil	Univ. of Newcastle

In this paper the tracking and analytical infrastructure necessary to adequately understand and manage the power demands of a fleet of electric vehicles is considered. The data from a 230 day trial of 15 electric vehicles has been used to simulate a single day with over 3000 vehicles on the road within the North East of England. Current analytical approaches are considered and possible future avenues are addressed. A general model for predicting the probability of a vehicle charging is proposed. The comparative charging rates between morning and evening and the spatial distribution of the charging are all considered. It is found that although the evening charging has the greater number of charging events across the region it is the morning charges which pose the most risk for local power management as the morning charges tend to be concentrated within a smaller spatial extent. In more general terms the use of individual vehicle tracking systems is found to be an ideal system for determining the current and future state of power consumption for electric vehicles which is important to inform decision makers and politicians on the future needs for electric vehicle charging infrastructure and the electricity distribution network necessary to supply them - as the numbers of such vehicles on the road increases from minimal to significant.

09:50-11:20	WePO5S.24

Effects of Discomfort Glare on Peripheral Visual Attention in a Driving Simulator, pp. 920-925

Huang, Ying-Yin	ETH Zurich
Menozzi, Marino	ETH Zurich

Discomfort glare is considered to have some influence on a person's driving performance, but its effects are not well understood. It is likely that discomfort glare may irritate and distract one's visual system during driving. In our everyday driving tasks, we must pay attention to visual information on the road to ensure driving safety, not only in the central visual field, but also in the periphery. Furthermore, with the increasing usage of head-up displays (HUDs) in modern times, we need to consider the displayed information as well, which increases the load of processing the visual information. For safety reasons, and for enhancing driving quality, this study explored possible effects of mild glare scenes on one's peripheral visual attention. Visual stimuli presented in the central visual field and at 18° in the peripheral visual field were applied in a driving simulator in a virtual reality environment. Visual tasks were projected on a 3m by 3m projection wall at a distance of 3m to the observer. 50% of the visual tasks had a mild glare scene with a luminance of 25 cd/m2 flashed before the stimulus. Results of forty-one participants showed that the mean rates of correct answers were 80.97% and 84.66% with and without applying glare respectively. We applied the theory of signal detection to analyze the experimental results. Analyzed data showed a significant difference (two-tailed t-test for dependent samples, $p < 0.001$) in detectability d' (d'with glare= 1.96; d'without glare= 2.36; Δd' = 0.39). Therefore, discomfort glare causes peripheral visual attention impairment in a driving simulator in a virtual reality environment.

09:50-11:20	WePO5S.25

Performance Analysis of a Scalable Navigation Solution Using Vehicle Safety Sensors, pp. 926-931

Martin, Scott	Auburn Univ.
Rose, Christopher	Auburn Univ.
Britt, Jordan	Auburn Univ.
Bevly, David	Auburn Univ.
Popovic, Zeljko	Honda R & D Americas, Inc.

GPS receiver performance can suffer in difficult environments such as urban canyons and heavy foliage. Inertial sensors provide information between GPS updates and can enhance the position solution in a GPS/INS architecture. Additional information from safety sensors already on the vehicle, such as lane departure warning (LDW) sensors, can enhance the navigation solution further by constraining inertial errors even in the presence of GPS errors. This paper outlines a scalable navigation solution that can use a combination of GPS, reduced inertial sensors, full inertial data, vehicle CAN data, and vision sensors, depending on what data is available in difficult environments. Data was collected in Detroit, Michigan in a diverse mix of environments that includes heavy foliage, highway, and downtown areas, in proportions representative of what is expected in typical driving. Validation of the approach consists of both a qualitative analysis of the resulting trajectories overlaid on a map of the area and quantitative comparison of the trajectories produced by the proposed system and the reference system.

09:50-11:20	WePO5S.26

Advanced Intersection Management for Connected Vehicles Using a Multi-Agent Systems Approach, pp. 932-937

Jin, Qiu	Univ. of California, Riverside
Wu, Guoyuan	Univ. of California-Riverside
Boriboonsomsin, Kanok	Univ. of California-Riverside
Barth, Matthew	Univ. of California-Riverside

Transportation is responsible for approximately a third of greenhouse gases (GHG) and a major source of other pollutants including hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx). Intelligent Transportation System (ITS) technology can be used to lower vehicle emissions and fuel consumption, in addition to reducing traffic congestion, smoothing traffic flow, and improving roadway safety. As wireless communication advances, connected-vehicles-based Advanced Traffic Management Systems (ATMS) have gained significant research interest due to their high potential. In this study, we examine the concept of ATMS for connected vehicles using a multi-agent systems approach, where both vehicle agents and an intersection management agent can take advantage of real-time traffic information exchange. This dynamic strategy allows an intersection management agent to receive state information from vehicle agents, reserve the associated intersection time-space occupancies, and then provide feedback to the vehicles. The vehicle agents then adjust their trajectories to meet their assigned time slot. Based on preliminary simulation experiments, the proposed strategy can significantly reduce fuel consumption and vehicle emissions compared to traditional signal control systems.

09:50-11:20	WePO5S.27

Development of 'Intelligent Pioneer' Unmanned Vehicle, pp. 938-943

Mei, Tao	Chinese Acad. of Sciences

The paper presents the architecture of an unmanned vehicle called 'Intelligent Pioneer' developed by the authors. The unmanned vehicle has the ability of navigating in urban environments autonomously without GPS or any other satellite navigation system. The vehicle is able to select its own routes by perceive the traffic signs and interact with other vehicles or pedestrians under the traffic rules. Various urban driving skills including lane keeping, U-turns, parking, obstacle avoidance, and merging into moving traffic have been developed for the vehicle. The vehicle attended the Future Challenge of Intelligent Vehicles in China organized by National Nature Science Foundation of China in 2010 and 2011. 'Intelligent Pioneer' finished all of the competition programs and won the first position in 2010 and the third position in 2011.

WeOR1S	Room T1
Driver Assistance Systems II (Regular Session)	
Chair: Wanielik, Gerd	Chemnitz Univ. of Tech.

11:20-11:40	WeOR1S.1

Effectiveness of Forward Collision Warnings for Different Driver Attention States, pp. 944-949

Ovcharova, Neli	Robert Bosch GmbH
Fausten, Michael	Robert Bosch GmbH
Gauterin, Frank	Inst. of Vehicle System Tech. Karlsruhe Inst. of T

In recent years various collision warning systems for rear-end crash situations have been introduced into the market. Their goal is to reduce the number of fatalities and to mitigate collision consequences. The challenge in the design for such functions is to achieve a high effectiveness for both attentive and inattentive drivers. A possible approach could be an adaptation of the human-machine interface (HMI) to driver attentiveness levels. This paper presents a preliminary study of different visual-acoustical HMI concepts performed in a driving simulator. The participants completed two drives with each warning signal. In the first drive they were distracted by a secondary task and in the second one they were in an attentive state. The statistical analysis of the inattentive drivers' data showed a significant reaction time reduction by employing an acoustical speech warning. A visual alert for inattentive subjects did not result in an additional reduction. Only a simple and intuitive visual display showed a significant reduction of response time for attentive participants. The results of this study show that for varying driver attentiveness levels a warning intensity adaptation is needed in order to increase the benefit and acceptance of the collision warning.

11:40-12:00	WeOR1S.2

An Approach to Automotive ECG Measurement Validation Using a Car-Integrated Test Framework, pp. 950-955

Schneider, Johannes	FZI Res. Center for Information Tech.
Köllner, Christian	FZI Res. Center for Information Tech.
Heuer, Stephan	FZI Res. Center for Information Tech.

Development and integration of physiological sensors into automotive applications is gaining importance. Assistance systems which possess knowledge about the driver's cognitive state could increase road safety. In this paper we present a flexible framework that enables the development, evaluation and verification of sensors and algorithms for automotive applications using physiological signals under realistic driving conditions. We have integrated a custom capacitive ECG measurement system into a test car and validated its performance in real world driving tests. During first test runs, the capacitive system achieved a sensitivity of up to 95.5% and a precision rate of up to 92.6%. Our system also records synchronized vehicle dynamics. We discuss the road test measurements which suggest that the driving situation highly impacts the quality of ECG signal. Therefore, information on driving dynamics could be used to improve the precision rate of future capacitive ECG measurement.

12:00-12:20	WeOR1S.3

An Evaluation of Boosted Features for Vehicle Detection, pp. 956-961

Liu, Liwei	Tsinghua Univ.
Duan, Genquan	Tsinghua Univ.
Ai, Haizhou	Tsinghua Univ.
Lao, Shihong	OMRON Social Solutions Co., LTD.

Vehicle detection in traffic scenes is a fundamental task for intelligent transportation system and has many practical applications as diverse as traffic monitoring, intelligent scheduling and autonomous navigation. In recent years, the number of detection approaches in monocular images has grown rapidly. However, most of them focus on detecting other objects (such as face, pedestrian, cat, dog, etc.) and also there lacks of vehicle datasets with various conditions for vehicle detection and comprehensive comparisons. To address these problems, we perform an extensive evaluation of many state-of-the-art detection approaches on vehicles. Our main contributions are: (1) we collect a large dataset of real-world vehicles in frontal/rear view with 30 degrees to -30 degrees yaw changes and 5 degrees to 45 degrees pitch changes under different weather conditions (snowy, rainy, sunny and cloudy) and illumination variations, and then (2) we evaluate six types of state-of-the-art features in Real AdaBoost framework on the adequate dataset collected by ourselves and a public dataset using the same evaluation protocol. Our study presents a fair comparison and deep analysis of these features in vehicle detection. From these experiments, we explore the characteristics of good features for vehicle detection. (3) Finally, we exploit these characteristics and propose a relatively effective and efficient detector, balancing performance, speed and memory cost which can be put into practical use.

12:20-12:40	WeOR1S.4

Generalized Probabilistic Data Association for Vehicle Tracking under Clutter, pp. 962-968

Schubert, Robin	BASELABS GmbH
Adam, Christian	Chemnitz Univ. of Tech.
Richter, Eric	BASELABS GmbH
Bauer, Sven	Chemnitz Univ. of Tech.
Lietz, Holger	Chemnitz Univ. of Tech.
Wanielik, Gerd	Chemnitz Univ. of Tech.

Vehicle tracking under clutter is an important prerequisite for numerous vehicular applications. In this paper, we propose a generalization of the existing integrated probabilistic data association method in order to model situations where several true and additional clutter observations originated from one object. We will show that the proposed method outperforms the existing one. Furthermore, we will demonstrate a system utilizing a camera sensor and the proposed algorithm for detecting and tracking vehicles under clutter.

WeOR2S	Room T1
Sensors (Regular Session)	
Chair: Himmelsbach, Michael	Univ. of the Bundeswehr, Munich

13:50-14:10	WeOR2S.1

Modeling and Validation of a New Generic Virtual Optical Sensor for ADAS Prototyping, pp. 969-974

Gruyer, Dominique	IFSTTAR
Grapinet, Mélanie	IFSTTAR - LEMCO
Desouza, Philippe	CIVITEC

In the early design stages of embedded applications, it becomes necessary to have a very realistic simulation environment dedicated to the prototyping and to the evaluation of these Advanced Driving Assistance Systems (ADAS). This Numerical simulation stage is gradually becoming a strong advantage in active safety. The use of realistic numerical models enabling to substitute real data by simulated data is primordial. For such virtual platform it is mandatory to provide physics-driven road environments, virtual embedded sensors, and physics-based vehicle models. In this publication, a generic solution for cameras modelling is presented. The use of this optical sensor simulation can easily and efficiently replace real camera test campaigns. This optical sensor is very important due to the great number of applications and algorithms based on it. The presented model involves a filter mechanism in order to reproduce, in the most realistic way, the behaviour of optical sensors. The main filters used in ADAS developments will be presented. Moreover, an optical analysis of these virtual sensors has been achieved allowing the confrontation between real and simulated results. An optical platform has been developed to characterize and validate any camera, permitting to measure their performances. By comparing real and simulated sensors with this platform, this paper demonstrates this virtual platform (Pro-SiVIC™) accurately reproduces real optical sensors' behaviour.

14:10-14:30	WeOR2S.2

Lane Recognition for Moving Vehicles Using Multiple On-Car RFID Receiver Antennas - Algorithm and Its Experimental Results, pp. 975-981

Togashi, Hiroaki	The Graduate Univ. for Advanced Studies
Borcea, Cristian	New Jersey Inst. of Tech.
Yamada, Shigeki	National Inst. of Informatics

Accurate lane recognition for moving vehicles is important for lane keeping and lane changing assistance systems. Additionally, this information could be leveraged by ITS (Intelligent Transportation Systems) to suggest lane changes for improved traffic load balancing across lanes. This paper presents a position estimation algorithm for moving vehicles based on RFIDs placed on roadsides and lane boundaries, and multiple on-car RFID receiver antennas. To improve location accuracy, the algorithm proposes two novel ideas: (1) compute pair-wise estimations of on-car antennas using the RSSI of all pairs of RFID signals received, and (2) use a dynamic weighting function to assign higher weights to the positions estimated based on closer RFIDs. The results from our field experiments indicate that the proposed method achieved 0.7-meter localization accuracy for the position estimation when RFIDs were placed at 0.5-meter intervals and a vehicle has 8-antennas. This accuracy allows a moving vehicle to recognize which lane it is in. The localization accuracy of the proposed method was found to be mostly stable for any kind of road shape and any number of lanes. This paper also considers some improved schemes towards achieving a higher level of accuracy. A 14% percentage accuracy improvement is achieved when RFIDs were placed at 0.25m intervals and the RFIDs located farther than 30m were excluded from computation.

14:30-14:50	WeOR2S.3

Noise Model for Car-Embedded Speech Acquisition System Design, pp. 982-986

Ayllon, David	Univ. of Alcala
Gil-Pita, Roberto	Univ. of Alcala
Utrilla-Manso, Manuel	Univ. of Alcala
Rosa-Zurera, Manuel	Univ. of Alcala

Intelligent vehicles provide several speech-based advanced features, which success rely on the robustness of the speech acquired by the vehicle microphone system. This speech can be enhanced with a microphone array by means of spatial filtering, which design needs a reliable noise model to guarantee good filtering performance. Traditionally, it has been assumed that this noise is diffuse, but different measurements in real scenarios revel that the coherence of the noise is high to consider that is completely diffuse. In this paper, we suggest that the major contribution of the noise in a car can be reduced to a finite number of uncorrelated noise sources. We propose a searching algorithm to identify the position of the most uncorrelated sources, obtaining also their relative energy. This model allows to generate reliable synthetic noise based on real measurements, which can be very useful in the design of spatial filters.

14:50-15:10	WeOR2S.4

Accident Reproduction System for the Identification of Human Factors Involved on Traffic Accidents, pp. 987-992

S. Siordia, Oscar	Univ. Rey Juan Carlos
Martín de Diego, Isaac	Univ. Rey Juan Carlos
Conde, Cristina	Univ. Rey Juan Carlos
Cabello, Enrique	Univ. Rey Juan Carlos

In this paper, a novel accident reproduction system for the identification of the main human factors involved on traffic accidents is presented. The system is based on a wireless in-vehicle Electronic Data Recorder that could be easily installed in any vehicle's cabin for the monitoring of the three basic elements of traffic safety: driver, road and vehicle. The system has been tested in a highly realistic truck simulator with a group of professional drivers. The data, collected with the system at the moments before traffic accidents, were used to generate a novel database that was carefully analyzed by a group of traffic safety experts. The validation process shows the reliability of the developed system as a tool for the identification of the main causes of the monitored traffic accidents.

WePO6S	Room T1
Poster Session VI (Poster Session)	
Chair: Guo, Chunzhao	Toyota Tech. Inst.

15:10-16:40	WePO6S.1

Indoor Micro Navigation Utilizing Local Infrastructure-Based Positioning, pp. 993-998

Einsiedler, Jens	Fraunhofer Inst. for Open Communication Systems
Sawade, Oliver	Fraunhofer Inst. for Open Communication Systems
Schäufele, Bernd	Daimler Center for Automotive Information Tech.
Witzke, Marcus	Daimler Center for Automotive Information Tech. Innovations
Radusch, Ilja	Daimler Center for Automotive Information Tech. Innovations

In this paper we present an indoor micro-navigation system for enclosed parking garages. It builds on car-to-infrastructure communication to provide layout information of the car park, the coordinates of the destination parking lot, as well as external positioning information to vehicles. In our approach we use customary network video cameras to detect and locate vehicles within the car park. Once a vehicle is detected, the system correlates the position of the vehicle to the car park layout and transmits this information to the appropriate vehicle to substitute the internal positioning system. With this information the vehicle is guided from the car park entrance to a destination parking lot.

15:10-16:40	WePO6S.2

Sensor Clouds for Intelligent Truck Monitoring, pp. 999-1004

Zingirian, Nicola	Univ. of Padova
Valenti, Carlo	Click & Find s.r.l.

The paper presents a new service paradigm for Vehicle Communication Platforms (VCPs), based on the Sensor Cloud concept. According to this paradigm, VCPs make available their components, including vehicle sensor and devices, to third-party vehicle monitoring applications, as virtual resources. We prototyped a Sensor Cloud service on the Click & Find™ VCP, currently supporting real-time Intelligent Truck Monitoring (ITM) services on about one thousand tank trucks for fuel distribution in Europe. The paper presents the Sensor Cloud service architecture and implementation, discussing the main benefits delivered to the ITM domain.

15:10-16:40	WePO6S.3

Driving Coach: A Smartphone Application to Evaluate Driving Efficient Patterns, pp. 1005-1010

Araújo, Rui	Faculdade de Engenharia da Univ. do Porto
Igreja, Ângela	Faculdade de Engenharia da Univ. do Porto
de Castro, Ricardo	Faculdade de Engenharia da Univ. do Porto
Esteves Araújo, Rui	Faculdade de Engenharia, Univ. do Porto

In spite of several technical advances made in recent years by the automotive industry, the driver's behaviour still influences significantly the overall fuel consumption. With the rise of smartphones adoption, there are also new opportunities to increase the awareness to this issue. The main aim of this paper is to present a new smartphone application that will help drivers reduce the fuel consumption of their vehicles. This is accomplished by using the smartphone's sensors and the vehicle state to detect the driving pattern and suggest new behaviours in real time that will lead to a more efficient driving experience. The preliminary results show the potential for significant energy savings and their relevance for changing the drivers' behaviour.

15:10-16:40	WePO6S.4

Driver'a Authority Monitoring System for Intelligent Vehicles: A Feasibility Study, pp. 1011-1016

Uluer, Pinar — Galatasaray Univ.
Gocmenoglu, Can — Galatasaray Univ.
Acarman, Tankut — Galatasaray Univ.

One of the most challenging factors in the development of autonomous vehicles and advanced driver assistance systems is the imitation of an expert driver system which is the observer and interpreter of the technical system in the related driving scenario. In this paper, a multimodal adaptive driver assistance system is presented. The main goal is to determine the human driver's attention and authority level by decoupling the driver's vehicle control in the longitudinal and lateral directions in order to trigger timely warnings according to his/her driving intents and driving skills with respect to the possible driving situation and hazard scenarios. The presented driver assistance system considers the driver's driving performance metric sampled during the longitudinal and lateral vehicle control tasks as well as the processed information about the surrounding traffic environment consisting of the interactions with the other vehicles and the road situations. Experiments on a simulator are performed and the presented metric is calculated for the evaluation of the human driver's driving performance with respect to adaptive cruising and obstacle avoidance maneuvering tasks.

15:10-16:40 WePO6S.5

Evaluation of Compression Algorithms for Automotive Stereo Matching, pp. 1017-1022

Forster, Julian — Daimler AG
Jiang, Xin — Tech. Univ. of Munich
Terzis, Anestis — Ulm Univ. of Applied Sciences
Rothermel, Albrecht — Univ. of Ulm

Automotive stereo-based camera systems are at the focus of new vehicle functions development. Advantageous interconnections between automotive cameras and electronic control units are possible using IP-based technology in the vehicles. Because automotive implementation of this technology allows only limited data rates camera stream compression is necessary to transmit over such a medium. The image processing algorithms can be applied after a decompressing of the camera streams. This paper introduces a method for comparing the impact of different image compression algorithms on automotive stereo algorithms. We propose a comparison metric based on disparity error to compare the effects as a function of image compression algorithms, compression ratio and vehicle velocity.

15:10-16:40 WePO6S.6

Modular Approach to Energy Efficient Driver Assistance Incorporating Driver Acceptance, pp. 1023-1028

Themann, Philipp — Inst. für Kraftfahrzeuge, RWTH Aachen Univ.
Eckstein, Lutz — RWTH Aachen

The deployment of predictive driving styles reduces fuel consumption of vehicles significantly, while assistance systems can support drivers in this task. This paper describes a modular approach to consider various sources of information as well as different driver and vehicle types in the prediction and the optimization of the vehicle's longitudinal dynamics to reduce fuel consumption. Energy efficient driving strategies such as roll out or fuel cut-off are compared to the average driving behavior of the driver. The utility of the efficient strategies is assessed relative to the average driver behavior, which is similar to human information processing. Resulting optimal driving strategies are provided to the driver as recommendations or applied to vehicles by intervening assistance systems such as adaptive cruise control. This paper aims to summarize the basic methodology of the approach.

15:10-16:40 WePO6S.7

Fast Iterative Closest Point Framework for 3D LIDAR Data in Intelligent Vehicle, pp. 1029-1034

Choi, Won-Seok — POSTECH
Kim, Yang-Shin — POSTECH
Oh, SeYoung — Pohang Univ. of Science and Tech.
Lee, Jeihun — LG Electronics Advanced Res. Inst.

The Iterative Closest Point (ICP) algorithm is one of the most popular methods for geometric alignment of 3-dimensional data points. We focus on how to make it faster for 3D range scanner in intelligent vehicle. The ICP algorithm mainly consists of two parts: nearest neighbor search and estimation of transformation between two data sets. The former is the most time consuming process. Many variants of the k-d trees have been introduced to accelerate the search. This paper presents a remarkably efficient search procedure, exploiting two concepts of approximate nearest neighbor and local search. Consequently, the proposed algorithm is about 24 times faster than the standard k-d tree.

15:10-16:40 WePO6S.8

Real-Time Pedestrian Detection with Deformable Part Models, pp. 1035-1042

Cho, Hyunggi — Carnegie Mellon Univ.
Rybski, Paul — Carnegie Mellon Univ.
Bar Hillel, Aharon — General Motors
Zhang, Wende — GM R&D

We describe a real-time pedestrian detection system intended for use in automotive applications. Our system demonstrates superior detection performance when compared to many state-of-the-art detectors and is able to run at a speed of 14 fps on an Intel Core i7 computer when applied to 640480 images. Our approach uses an analysis of geometric constraints to efficiently search feature pyramids and increases detection accuracy by using a multiresolution representation of a pedestrian model to detect small pixel-sized pedestrians normally missed by a single representation approach. We have evaluated our system on the Caltech Pedestrian benchmark which is currently the largest publicly available pedestrian dataset at the time of this publication. Our system shows a detection rate of 61% with 1 false positive per image (FPPI) whereas recent other state-of-the-art detectors show a detection rate of 50% ~ 61% under the ‘reasonable' test scenario (explained later). Furthermore, we also demonstrate the practicality of our system by conducting a series of use case experiments on selected videos of Caltech dataset.

15:10-16:40 WePO6S.9

DAARIA: Driver Assistance by Augmented Reality for Intelligent Automobile, pp. 1043-1048

George, Paul — Univ. de Tech. de Compiègne
Thouvenin, Indira — Heudiasyc CNRS Lab. Univ. of Tech. Compiegne
Fremont, Vincent — Univ. de Tech. de Compiègne
Cherfaoui, Véronique — Univ. Tech. Compiègne

Taking into account the drivers' state is a major challenge for designing new advanced driver assistance systems. In this paper we present a driver assistance system strongly coupled to the user. DAARIA 1 stands for Driver Assistance by Augmented Reality for Intelligent Automobile. It is an augmented reality interface powered by several sensors. The detection has two goals: one is the position of obstacles and the quantification of the danger represented by them. The other is the driver's behavior. A suitable visualization metaphor allows the driver to perceive at any time the location of the relevant hazards while keeping his eyes on the road. First results show that our method could be applied to a vehicle but also to aerospace, fluvial or maritime navigation.

15:10-16:40 WePO6S.10

Modeling Car-Following Behavior As Instantaneous Maximization of Drivers' Utility for Estimation of Traffic Level of Service, pp. 1049-1054

Kasai, Makoto — Tokyo Univ. of Science

This study points out the importance of estimating the traffic service level. For the estimation, a car-following model is proposed based on the assumption that a driver tries to adjust acceleration to maximize utility instantaneously. Two types of data are applied for model verification: data from a probe car that are precise but probably biased, and data from a video camera which are not expected to be very precise. The fundamental performance of the car-following model is verified with data from the probe car. The model generally fits to drivers' data taken from video image, and individual differences—

which are probably not negligible when estimating drivers' satisfaction—in the parameters of the model is revealed. An experimental estimation of chronological changes in drivers' utility caught by video footage is tested as an application of this model.

15:10-16:40 WePO6S.11

Visible Light Communications: Application to Cooperation between Vehicles and Road Infrastructures, pp. 1055-1059

Cailean, Alin Mihai — Univ. of Versailles, LISV
Cagneau, Barthélemy — LISV - Univ. de Versailles
Chassagne, Luc — LISV-Univ. de Versailles
Topsu, Suat — Univ. of Versailles
Alayli, Yasser — LISV - Univ. de Versailles
Blosseville, Jean-marc — IFSTTAR

The last couple of years, the vehicle industry tends to increase the performance of lights based on led technologies. Nowadays, led systems are used as a standard by motor vehicles manufacturers. Led lights present higher reliability and are more flexible regarding design or power adjustments. Furthermore, led systems are also very convenient for intensity modulation used in telecommunication fields. We developed a very simple data transmission system based on led lights which is highly robust for short or medium distances – from a few meters up to 15 meters. This visible light communication is dedicated to the cooperation between vehicles and road infrastructures to enhance traffic security. This paper explains the choices and first results on the data transmission performances. In this paper, we present a first prototype of our system and experimental results.

15:10-16:40 WePO6S.12

Moving Objects Detection and Recognition Using Sparse Spatial Information in Urban Environments, pp. 1060-1065

Li, You — Univ. de Tech. de Belfort-Montbeliard
Ruichek, Yassine — Univ. of Tech. of Belfort-Montbeliard

Moving objects detection and recognition around an intelligent vehicle are active research fields and a large number of approaches have been proposed in recent decades. This paper proposes a novel approach based solely on spacial information to solve this problem. Moving objects detection is achieved in conjunction with an ego-motion estimation by sparse matched feature points. For objects recognition, we firstly present a method to boost simple spacial information by Kernel Principal Component Analysis (KPCA). Then, two kinds of classifiers (Random Forest and Gradient Boosting Trees) are trained off-line to recognize several common categories of moving objects in urban scenarios (vehicle, pedestrian, cyclist, ...). Experiments are implemented and the results confirm the effectiveness of the proposed algorithm. Furthermore, a comparison to a previous similar method is performed to verify the enhancement of classification by the advanced spacial features.

15:10-16:40 WePO6S.13

Efficient Stixel-Based Object Recognition, pp. 1066-1071

Enzweiler, Markus — Daimler AG
Hummel, Matthias — Daimler AG
Pfeiffer, David — Daimler AG
Franke, Uwe — Daimler AG

This paper presents a novel attention mechanism to improve stereo-vision based object recognition systems in terms of recognition performance and computational efficiency at the same time. We utilize the Stixel World, a compact medium-level 3D representation of the local environment, as an early focus-of-attention stage for subsequent system modules. In particular, the search space of computationally expensive pattern classifiers is significantly narrowed down. We explicitly couple the 3D Stixel representation with prior knowledge about the object class of interest, i.e. 3D geometry and symmetry, to precisely focus processing on well-defined local regions that are consistent with the environment model.

Experiments are conducted on large real-world datasets captured from a moving vehicle in urban traffic. In case of vehicle recognition as an experimental testbed, we demonstrate that the proposed Stixel-based attention mechanism significantly reduces false positive rates at constant sensitivity levels by up to a factor of 8 over state-of-the-art. At the same time, computational costs are reduced by more than an order of magnitude.

15:10-16:40 WePO6S.14

An Embedded Calibration Stereovision System, pp. 1072-1077

Jia, Yunde — Beijing Inst. of Tech.
Qin, Xiameng — Beijing Inst. of Tech.

This paper describes an embedded calibration stereovision system that is able to be strongly online and auto-calibrated without placing a calibration device in front of the stereo camera, but with the device hidden inside the cavity of the system via a half-mirror. The stereo camera simultaneously observes a scene passing through the half-mirror and the calibration device reflected from the half-mirror, and makes the formation of an embedded calibration stereo pair containing both scene and the calibration device. The features of the calibration patterns are extracted from the embedded calibration stereo pair to estimate the stereo camera's parameters. We use a polyhedral-mirror to generate multiple virtual images of the calibration device to occupy large part of a scene image for accurate estimation. We also use several mirrors to extend the optical path from the calibration device to the stereo camera for depth recovery of distance objects. The system can be easily used in a wide range of applications without considering variation of camera parameters.

15:10-16:40 WePO6S.15

Practical Testing Application of Travel Time Estimation Using Applied Monte Carlo Method and Adaptive Estimation from Probes, pp. 1078-1083

Hadachi, Amnir — INSA DE ROUEN
Mousset, Stéphane — INSA/Univ. de ROUEN
Bensrhair, Abdelaziz — National Inst. of Applied Sciences-Rouen,

This paper presents a practical testing of two different methods to estimate the travel time in urban areas. The purpose behind this testing is to validate the behavior of each method regarding the road aspect in urban areas. The first method is based on Monte Carlo Method and the second one is based on adaptive estimation from probes. Both methods were modified to be adapted to our case and also to the nature of our data. The paper also describes an experiment with real-world data that was used in the testing of the two methods. Moreover it contains the architecture of the system used in order to make the tests.This work yeilded interesting results based on real-world experiments which give clear feedback about the application of the two methods to compute the travel time estimation per road section that can be used for processing the historical database as well as real time data. In general this work is a suitable validation of the two methods and encouraging for our future perspectives.

15:10-16:40 WePO6S.16

A Novel Multi-Lane Detection and Tracking System, pp. 1084-1089

Zhao, Kun — Univ. Duisburg-Essen
Meuter, Mirko — Delphi Electronics & Safety
Nunn, Christian — Delphi Electronics and Safety
Mueller, Dennis — Delphi Electronics & Safety
Müller-Schneiders, Stefan — Delphi Deutschland GmbH
Pauli, Josef — Univ. Duisburg-Essen

In this paper a novel spline-based multi-lane detection and tracking system is proposed. Reliable lane detection and tracking is an important component of e.g. lane departure warning systems, lane keeping support system or lane change assistance systems. The major novelty of the proposed approach is the usage of the so-called Catmull-Rom spline in combination with the extended Kalman filter tracking. The new spline-based model enables an accurate and flexible modeling of the lane markings. At the same time the application of the extended Kalman filter contributes significantly to the system robustness and stability. There is no assumption about the parallelism or the shapes of the lane markings in our method. The number of lane markings is also not restrained, instead each lane marking is separately modeled and tracked. The system runs on a standard PC in real time (i.e. 30 fps) with WVGA image resolution (752*480) . The test vehicle has been driven on the roads with challenging scenarios, like worn out lane markings, construction sites, narrow corners, exits and entries of the highways, etc., and good

performance has been demonstrated. The quantitative evaluation has been performed using manually annotated video sequences.

15:10-16:40 WePO6S.17

Fast Visual Road Recognition and Horizon Detection Using Multiple Artificial Neural Networks, pp. 1090-1095

Shinzato, Patrick — Univ. of Sao Paulo
Wolf, Denis — Univ. of Sao Paulo
Osorio, Fernando — USP - Univ. of Sao Paulo
Grassi Jr, Valdir — Univ. of Sao Paulo

The development of autonomous vehicles is a highly relevant research topic in mobile robotics. Road recognition using visual information is an important capability for autonomous navigation in urban environments. Over the last three decades, a large number of visual road recognition approaches have been appeared in the literature. This paper proposes a novel visual road detection system based on multiple artificial neural networks that can identify the road based on color and texture. Several features are used as inputs of the artificial neural network such as: average, entropy, energy and variance from different color channels (RGB, HSV, YUV). As a result, our system is able to estimate the classification and the confidence factor of each part of the environment detected by the camera. Experimental tests have been performed in several situations in order to validate the proposed approach.

15:10-16:40 WePO6S.18

Driver Behavior Monitoring System Based on Traffic Violation, pp. 1096-1101

Aliane, Nourdine — Univ. Europea de Madrid
Fernandez, Javier — Univ. Europea de Madrid
Bemposta Rosende, Sergio — Univ. Europea de Madrid
Mata, Mario — Univ. europea de madrid

This paper describes the overall framework and components of an experimental platform for driver behavior monitoring based on driver's traffic violation records. This platform is composed of two separate subsystems: a driver assistance system based on road sign detection and recognition, and a traffic violation recording unit in which the vehicle is involved. The system provides drivers with their traffic violation records allowing them to visualize the spatial and temporal information of their traffic violation using the standard Google Earth tool. This feedback can be used to persuade drivers in changing their driving styles by instilling improved behavior. The paper covers firstly the description of the hardware architecture and then presents the developed functionalities.

15:10-16:40 WePO6S.19

Detection of Abnormal Driving Using Multiple View Geometry in Space-Time, pp. 1102-1107

Saruwatari, Kota — Nagoya Inst. of Tech.
Sakaue, Fumihiko — Nagoya Inst. of Tech.
Sato, Jun — Nagoya Inst. of Tech.

In this paper, we propose a method for detecting abnormal driving of vehicles, such as meandering, transverse motion and acceleration/deceleration. In particular, we extract abnormal vehicle motions in the sense of group behavior by using multilinear relationship in space-time images. The multilinear relationship in space-time images holds when multiple cameras move with translational motions in different direction with different speed. Therefore abnormal drivings, which are not translational motion with uniform velocity, do not meet the requirement, and the multilinear relationship in space-time images does not hold. We focus on this property, and define the degree of abnormality, which is used for detecting abnormal drivings. The efficiency of the proposed method is shown by real image experiments.

15:10-16:40 WePO6S.20

Path Following with Backtracking Based on Fuzzy Controllers for Fordward and Reverse Driving, pp. 1108-1113

Pérez, Joshué — Automation and Robotics Centre
Godoy, Jorge — Automation and Robotics Centre
Milanés, Vicente — AUTOPIA program, CAR
Villagra, Jorge — Automation and Robotics Centre
Onieva, Enrique — Center for Automation and Robotics

Autonomous navigation is one of the most important challenges in the outdoor mobile robot field. For an automatic vehicle (which can be considered a type of outdoor mobile robot), path following can be implemented using global positioning systems (GPS) to allow the configuration of different navigation styles such as the shortest or fastest route, toll avoidance, etc., and even the definition of new routes. The main problem is when an unexpected circumstance occurs - traffic accident, road closure, etc. This paper presents an autonomous vehicle guidance system based on fuzzy logic systems to resolve unexpected road situations. A fuzzy steering controller performs the autonomous navigation, allowing reverse as well as forward driving in urban environments. Good performance was obtained in trials performed with a commercial electric Citroën Berlingo van on a private driving circuit.

15:10-16:40 WePO6S.21

Development of a Particle Swarm Algorithm for Vehicle Localization, pp. 1114-1119

Godoy, Jorge — Automation and Robotics Centre
Gruyer, Dominique — IFSTTAR
Lambert, Alain — IFSTTAR
Villagra, Jorge — Automation and Robotics Centre

This paper describes the development of a filter algorithm based on the behaviour of biological swarms. The main goal of the algorithm is to perform vehicle localization by combining the data from different sensors – GPS, IMU, speedometers, etc. – and digital maps. In this sense, the algorithm considers several solutions at the same time like Particles Filters. The algorithm has been developed offline using real data captured from an instrumented vehicle at LIVIC. Performance of the algorithm has been validated and compared with and EKF with encouraging results.

15:10-16:40 WePO6S.22

Intensity Self Similarity Features for Pedestrian Detection in Far-Infrared Images, pp. 1120-1125

Miron, Alina — INSA
Besbes, Bassem — National Inst. for Applied Sciences-Rouen
Rogozan, Alexandrina — National Inst. of Applied Sciences-Rouen
Ainouz-Zemouche, Samia — LITIS Lab. INSA de Rouen
Bensrhair, Abdelaziz — National Inst. of Applied Sciences-Rouen,

Pedestrian detection is an important but challenging component of an Intelligent Transportation System. In this paper, we describe a pedestrian detection system based on a monocular vision with a Far-Infrared camera (FIR). We propose an original feature representation, called Intensity Self Similarity (ISS), adapted to pedestrian detection in FIR images. The ISS representation is based on the relative intensity self similarity within a pedestrian region of interest (ROI) hypothesis. Our system consists of two components. The first component generates pedestrian ROI hypothesis by exploiting the specific characteristics of FIR images, where pedestrian shapes may vary in large scale, but heads appear usually as light regions. Pedestrian ROI are detected, with high recall rate, due to a Hierarchical Codebook (HC) of Speeded-Up Robust Features (SURF) located in light head regions. The second component consists of pedestrian hypothesis validation, by using a pedestrian full-body classification based on the ISS representation, with Support Vector Machine (SVM). For classification, we retained two feature descriptors: the Histogram of Oriented Gradients (HOG) descriptor and the original ISS feature representation that we proposed for FIR images. The early fusion of these two features enhances significantly the system precision, attaining an F-measure for the pedestrian class of 97.7%. Moreover, this feature fusion outperforms the state-of-the-art SURF descriptor proposed previously. The experimental evaluation shows that our pedestrian detector is also robust, since it performs well in detecting

pedestrians even in large scale and crowded real-world scenes.

15:10-16:40	WePO6S.23

Kinematic Constraints in Visual Odometry of Intelligent Vehicles, pp. 1126-1131

Jiang, Yanhua — Beijing Inst. of Tech.
Chen, Huiyan — Beijing Inst. of Tech.
Xiong, Guangming — Beijing Inst. of Tech.
Gong, Jianwei — Massachusetts Inst. of Tech.
Jiang, Yan — Beijing Inst. of Tech.

This paper presents a novel method to realize on-board visual odometry system. Vehicular kinematic constrain is used in the motion estimation algorithms. The work is a extension from planar steering model to 3-dof in which vehicle's motion is modeled more reasonable and accurate. By virtue of appropriate simplification, the close-form solution of motion parameters can be obtained only need to find real roots of a cubic equation. Then optimization based refine method can bring the winner solution to accurate solution utilizing inliers founded. The algorithm has been tested on both simulation platform and real car test and achieved promising results.

15:10-16:40	WePO6S.24

Image Based Fog Detection in Vehicles, pp. 1132-1137

Pavlic, Mario — BMW Group
Belzner, Heidrun — BMW Group
Rigoll, Gerhard — Munich Univ. of Tech.
Ilic, Slobodan — Tech. Univ. München

Modern vehicles are equipped with many cameras and their use in many practical applications is extensive. Detecting the presence of fog from images of a camera mounted in vehicles is a very challenging task with the potential to be used in many practical applications. Approaches introduced until now analyze properties of local objects in the image like lane markings, traffic signs, back lights of vehicles in front or head lights of approaching vehicles. By contrast to all these related works we propose to use image descriptors and a classification procedure in order to distinguish images with fog present from those free of fog. These image descriptors are global and describe the entire image using Gabor filters at different frequencies, scales and orientations. Our experiments demonstrated hight potential of the proposed method for fog detection on daytime images.

15:10-16:40	WePO6S.25

An Empirical Study on Optical Flow Accuracy Depending on Vehicle Speed, pp. 1138-1143

Onkarappa, Naveen — Computer Vision Center
Sappa, Angel D. — Computer Vision Center

Driver assistance and safety systems are getting attention nowadays towards automatic navigation and safety. Optical flow as a motion estimation technique has got major roll in making these systems a reality. Towards this, in the current paper, the suitability of polar representation for optical flow estimation in such systems is demonstrated. Furthermore, the influence of individual regularization terms on the accuracy of optical flow on image sequences of different speeds is empirically evaluated. Also a new synthetic dataset of image sequences with different speeds is generated along with the ground-truth optical flow.

15:10-16:40	WePO6S.26

Model-Based Detection and Tracking of Vehicle Using a Scanning Laser Rangefinder: A Particle Filtering Approach, pp. 1144-1149

Noyer, Jean Charles — Univ. Lille Nord de France
Wahl, Martine — Univ. Lille Nord de France, IFSTTAR, LEOST
Vanpoperinghe, Elodie — Univ. Lille Nord de France, IFSTTAR, LEOST

A method derived from the Sequential Monte Carlo approaches is proposed here to solve the vehicle detection and tracking problem using a scanning laser rangefinder. The originality of this approach lies in a joint detection and tracking of the objects that avoid the usual pre-detection stage. The proposed modeling is strongly nonlinear. To improve the efficiency of the solution, we use a Rao-Blackwell particle filter: the non-linearity of the state-space equations is taken into account by a particle filter and the linearity is optimally processed by a Kalman filter. The solution of the proposed modeling is based on a matched filter which uses a predefined vehicle model. A central point here is to calculate the weights of the matched particle filter according to the vehicle model. The efficiency of the method is shown in terms of estimation accuracies and detection.

15:10-16:40	WePO6S.27

Numerical Modeling of ADA System for Vulnerable Road Users Protection Based on Radar and Vision Sensing, pp. 1150-1155

Ruiz Garate, Virginia — Univ. Catholique de Louvain (UCL)
Bours, Roy C.H. — TNO Automotive Safety Solutions
Kietlinski, Kajetan Krzysztof — TASS Germany GmbH

The protection of vulnerable road users (VRU) remains one of the most challenging problems for our society and several governmental and consumer organization has set targets to reduce the VRU fatality and injury rates. The automotive industry is, therefore, developing pedestrian and cyclist detection systems that combine pre-crash sensing, risk estimation and vehicle dynamics control (braking, steering) with the objective to meet the challenging pedestrian and cyclist accident reduction targets set by various governments. The complexity of VRU detection makes the development process of these systems a complicated and time-consuming activity. Simulation software can help to overcome these difficulties by providing an efficient and safe environment for designing and evaluating VRU safety systems. This paper outlines the use of a software packages that provide the ability to cover all critical aspects of VRU safety design. It focuses on the sensing and control systems, as well as the evaluation of these systems for a range of different traffic scenarios. The presented system model uses fused information from vision sensor model (object classification) and radar model (collision estimation) for deploying autonomous braking and thus mitigate the effect of collision with VRUs.

15:10-16:40	WePO6S.28

Robotic Wheeled Vehicle Ripple Tentacles Motion Planning Method, pp. 1156-1161

Yu, Hongxiao — Beijing Univ. of Tech.
Gong, Jianwei — Massachusetts Inst. of Tech.
Iagnemma, Karl — Massachusetts Inst. of Tech.
Jiang, Yan — Beijing Inst. of Tech.
Duan, Jianmin — Beijing Univ. of Tech.

This paper describes a nonholonomic robotic wheeled vehicle ripple tentacle motion planning method, aiming to improve the vehicle's trajectory smoothness and avoid frequent weight parameters adjustment in different environments. In the regular tentacle motion planning algorithm, the planning result is selected among the drivable tentacles using a weighted sum cost function. Though the method is simple and easy to understand, it is difficult to adjust the weighted coefficients in different environments. To solve this problem, a geometrical ripple tentacles technique is used to choose a tentacle as a sub-optimal path. Compared with the regular tentacles algorithm, the proposed ripple tentacle algorithm can get a better performance in vehicle's trajectory smoothness with an acceptable runtime expense. And another two traits can also distinguish this method: (a) it can avoid weight parameter adjustment in different environments and varied vehicle's states, and (b) it can be used in both unknown environment and partly known environment with goal point and global reference path. In the totally unknown environment, it acts as a pure obstacle avoidance algorithm, and when there is a global path, it can follow the reference path and avoid hazards simultaneously.

WeOR3S	Room T1
Active and Passive Safety (Regular Session)	
Chair: Mugnai, Alexandre	TASS

16:40-17:00	WeOR3S.1

Driver Intent Inference at Urban Intersections Using the Intelligent Driver Model, pp. 1162-1167

Liebner, Martin — BMW Group Res. and Tech.
Baumann, Michael — BMW Group Res. and Tech.
Klanner, Felix — BMW Group

Stiller, Christoph — Karlsruhe Inst. of Tech.

Predicting turn and stop maneuvers of potentially errant drivers is a basic requirement for advanced driver assistance systems for urban intersections. Previous work has shown that an early estimate of the driver's intent can be inferred by evaluating the vehicle's speed during the intersection approach. In the presence of a preceding vehicle, however, the velocity profile might be dictated by car-following behaviour rather than by the need to slow down before doing a left or right turn. To infer the driver's intent under such circumstances, a simple, real-time capable approach using an explicit model to represent both car-following and turning behaviour is proposed. Models for typical turning behavior are extracted from real world data. Preliminary results based on a Bayes net classification are presented.

17:00-17:20 — WeOR3S.2

Field of Safe Travel: Using Location and Motion Information to Increase Driver Acceptance of Pedestrian Alerts, pp. 1168-1172

Smith, Kip — Cognitive Engineering and Decision Making, Inc

Källhammer, Jan-Erik — Autoliv Development AB

We investigated five contextual variables likely to influence driver acceptance of alerts to pedestrians issued by a night vision active safety system. Two of the five, pedestrian location and motion, were found to influence ratings. Hierarchical regression revealed that a nominal characterization of pedestrian location and two quantitative measures of motion explain more than 61% of the variance in driver ratings and do not interact. We discuss the implications of this finding for the specification of the system's alerting strategies.

17:20-17:40 — WeOR3S.3

A Novel Approach for the Probabilistic Computation of Time-To-Collision, pp. 1173-1178

Berthelot, Adam — Daimler AG

Tamke, Andreas — Daimler AG

Dang, Thao — Daimler AG

Breuel, Gabi — Daimler AG

Reliability and fault tolerance are very important criteria in the design and development of advanced driver assistance systems (ADAS). Modern driver assistance systems rely on several sources of information such as radar or image proces sing. A reliable system has to handle the uncertainty with the information it receives as input, in order to make robust and reliable decisions. In the situation analysis the Time metrics such as Time-To-Collision (TTC), Time-To-Brake (TTB), Time-To-React (TTR) are criticality measures assessing the risk potential of traffic situation. Such measures can be used to trigger warnings and emergency maneuvers in driver assistance systems. This paper presents an efficient algorithm to compute the probability distribution of TTC induced by an uncertain system input and thus allows to use TTC as a more robust and reliable probabilistic activation condition. The accuracy of the presented method was proven in the simulation using the example of several types of crossing scenarios.

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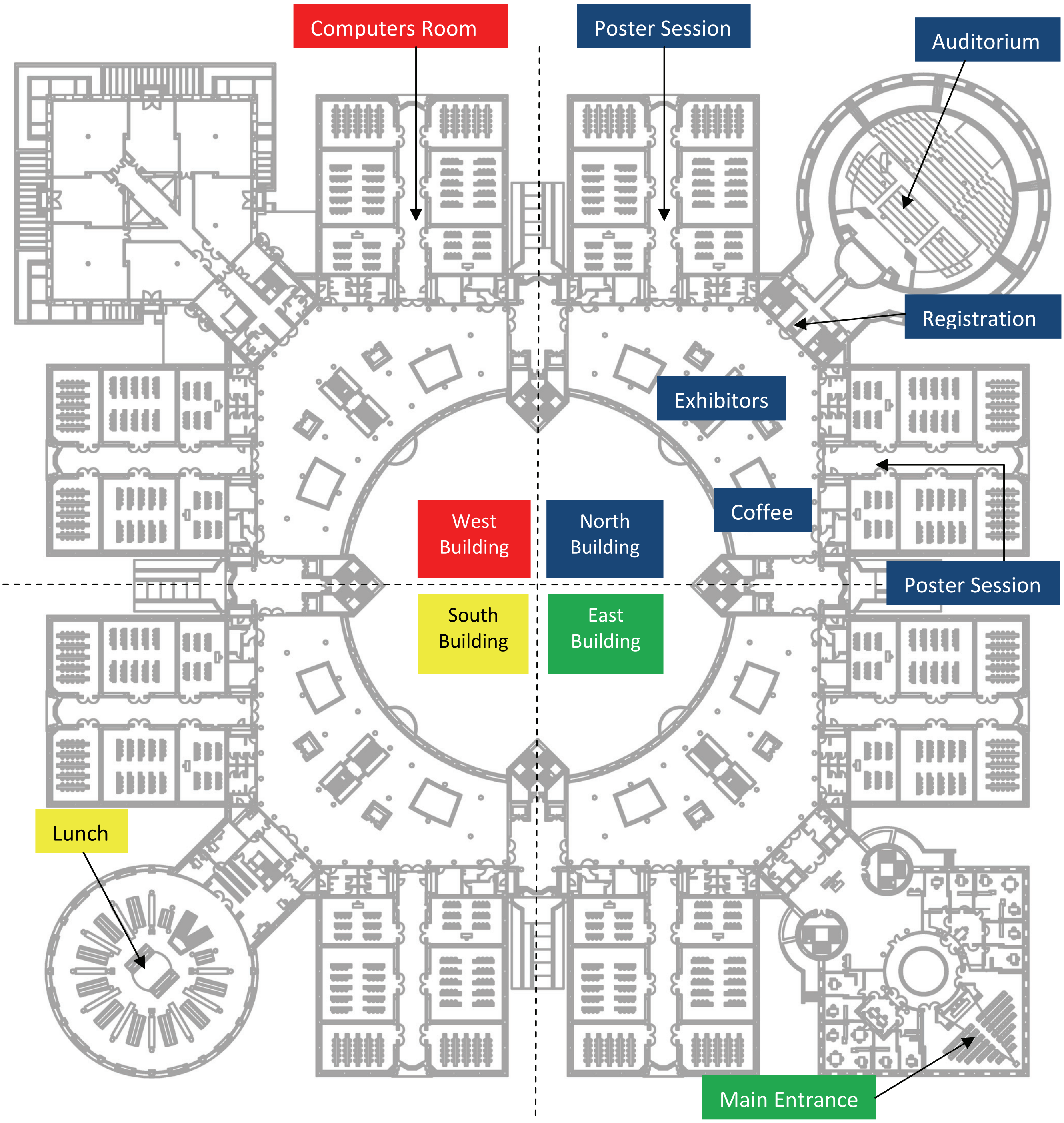
Floor Plans

Escuela Politécnica

North Building	*South Building – Basement*	*West Building*
Auditorium Poster Sessions Exhibitors Registration Coffee	Lunch	Computers Room



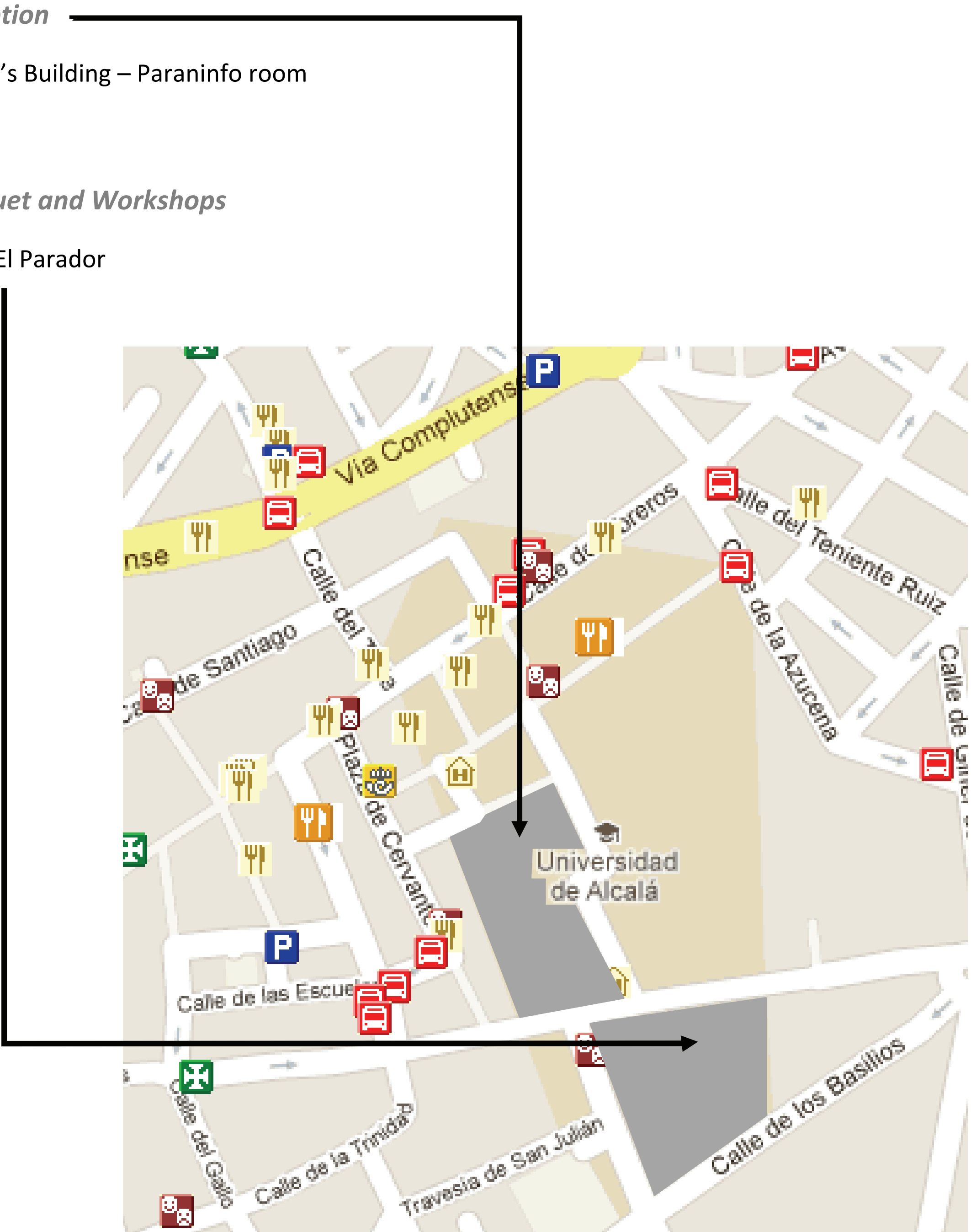
Alcalá de Henares

Reception

Rector’s Building – Paraninfo room

Banquet and Workshops

Hotel El Parador



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Program

Sunday June 3rd	Monday June 4th	Tuesday June 5th	Wednesday June 6th	Thursday June 7th
Workshops	8:30 Welcome Miguel Ángel Sotelo	8:45 Briefing & Coffee	8:45 Briefing & Coffee	Vehicle Demonstrations
	9:00 Keynote Chris Urmson	9:00 Keynote Dariu Gavrila	9:00 Keynote Robert Bertini	
	9:50 Poster Session MoPO1S	9:50 Poster Session TuPO3S	9:50 Poster Session WePO5S	
	11:20 Oral Session MoOR1S	11:20 Oral Session TuOR1S	11:20 Oral Session WeOR1S	
	12:50 Lunch	12:50 Lunch	12:50 Lunch	
	13:50 Oral Session MoOR2S	13:50 Oral Session TuOR2S	13:50 Oral Session WeOR2S	
	15:10 Poster Session MoPO2S	15:10 Poster Session TuPO4S	15:10 Poster Session WePO6S	
	16:40 Oral Session MoOR3S	16:40 Panel Discussion	16:40 Oral Session WeOR3S	
	19:30 Reception Paraninfo Room	21:00 Gala Dinner Hotel El Parador	17:40 Awards Ceremony	