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IEEE ITS SOCIETY NEWSLETTER

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Editor: Prof. Miguel Angel Sotelo, [miguel.sotelo@uah.es](mailto:miguel.sotelo@uah.es)

In This Issue

Society News and Announcements

<a href="#">Message from the Editor</a> .....	2
<a href="#">Message from the Past and New Presidents</a> .....	3
<a href="#">2013 Board of Governors Election Results</a> .....	5
<a href="#">2014 IEEE ITS Awards Call for Nomination</a> .....	6
<a href="#">2014 IEEE ITSS Best Ph.D. Dissertation Award Call for Application</a> .....	7
<a href="#">ITS Podcast</a> .....	8
<a href="#">An IEEE Women in Engineering/ITSS Event</a> .....	10

Featured Article

<a href="#">An Automated Truck Platoon within the Energy ITS Japan Project</a> .....	11
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Conferences and Call for Papers

<a href="#">2013 IEEE Intelligent Transportation Systems Conference Report</a> .....	15
<a href="#">2014 IEEE Intelligent Vehicles Symposium - Call for Papers</a> .....	19
<a href="#">2014 IEEE ITS Conference - Call for Papers</a> .....	20
<a href="#">IV14 Workshop on Human Factors in Intelligent Vehicles - CFP</a> .....	21
<a href="#">Conference Calendar</a> .....	24
<a href="#">Transactions on ITS Abstracts</a> .....	27
<a href="#">ITS Magazine Abstracts</a> .....	51
<a href="#">Officers and Committee Chairs</a> .....	52

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## Web Archive and Electronic Newsletter Subscription

The IEEE ITS Society Newsletter is published quarterly in January, April, July, and October. The current and all past issues of the Newsletter may be downloaded at no charge from the Society's web site: <http://sites.ieee.org/its/>.

You may subscribe to or unsubscribe from announcements at the same web site. Announcements are sent to approximately 16,000 ITS professionals from industry, academia, and government.

## Editorial Board

### Editor-in-Chief

Miguel Angel Sotelo [miguel.sotelo@uah.es](mailto:miguel.sotelo@uah.es)

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### Associate Editors

#### IEEE T-ITS and IEEE ITS-Magazine Report and Abstracts

Simona Berté .....[TransITS@ce.unipr.it](mailto:TransITS@ce.unipr.it)

#### Conferences, Workshops, and Journals

Massimo Bertozzi and Paolo Grisleri

.....[itsconfs@ce.unipr.it](mailto:itsconfs@ce.unipr.it)

### Information for Contributors

Announcements, feature articles, book and meetings reviews, opinions, letters to the editor, professional activities, Abstracts of reports, and other material of interest to the ITS community are solicited. Please submit electronic material for consideration in any of the following formats: Microsoft Word, OpenOffice, plain ASCII, rich text format (rtf), or portable document format (pdf) to the Editor-in-Chief at [miguel.sotelo@uah.es](mailto:miguel.sotelo@uah.es).

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## SOCIETY NEWS

### From the Editor

Miguel Ángel Sotelo



It is my pleasure to inform you that the ITSS family is growing at a steady and fast pace. Indeed, our ITS society has surpassed the remarkable figure of 1400 members, being the fastest growing IEEE society in 2013. Let us congratulate for that. In this issue, you will find the call for participation in our ITSS and Ph.D. Dissertation awards, as well as other call for papers and a featured article about the Energy ITS Project in Japan, by Prof. Sadayuki Tsugawa, that I hope will be of your interest. We will start this issue with the joint "Message from the Past and New Presidents" by Dr. Christoph Stiller and Dr. Matthew Barth, respectively.

I am pleased to announce that I have completed my service as Editor-in-Chief of the Newsletter and will transition this role to Dr. Brendan Morris from University of Nevada, USA. I am convinced that Brendan will do a brilliant work in this position as he has always done in his service to the ITSS. Brendan, welcome onboard and my best wishes for a bright future!

# Message from the Past and New Presidents

Every two years a new president of the IEEE Intelligent Transportation Systems Society is elected. Since January 1, 2014 the former President Christoph Stiller has become Past President and Matthew Barth has become President.

## Thank You for Two Exciting Years!

Dear IEEE ITS Society members:

Today, I am writing to you for the first time as Past President of the Society. When I started my term as President two years ago, my goals were to consolidate our activities, to carefully foster further expansion of the society's technical fields and activities and to further increase the benefits that our society offers to its members.

Foremost, I was overwhelmed by the huge interest that our society receives from the media, the public, and experts. I have received countless emails from all over the world about our conferences, publications, meetings, educational activities, and the expected evolution of technology in our field, and I hope I have satisfactorily answered or forwarded these to the appropriate contact persons. Our membership has grown substantially. Last year, ITSS has even been the fastest growing society in IEEE.

Our publications have grown by any measure. The Transactions on ITS have doubled in submissions and hold an excellent Impact Factor. Our young ITS Magazine has more than tripled the submissions and we expect to receive a high Impact Factor in mid 2014. Our Newsletter has a 16,000+ subscriber base. Two new publications have been launched with new formats: ITS Now!, organized by Daniel Zheng, is a new topical online publication. The ITS Podcast edited by Javier Sanchez Medina disseminates cutting-edge science and engineering research. In the last years our conferences have been breaking records in terms of submissions and participants and have become the gathering point of experts. We have initiated a student

## Let's Advance ITSS!

Dear IEEE ITS Society members:

It is my privilege and honor to serve as the IEEE Intelligent Transportation System Society's newest President. I have watched the society grow from its inception, attending nearly all of its conferences and events along the way. I am in awe of the efforts that the past presidents have made in growing our society into what it is today



and hope I can continue the trend. We are a very progressive IEEE society and I am certain we will continue to flourish and expand in the years to come. Interest in ITS is now at an all-time high—we have been

getting a significant amount of media attention lately with all of the discussions on automated vehicles, transportation electrification, and vehicles becoming increasingly connected to each other, along with the infrastructure. The future of ITS looks very promising!

Intelligent Transportation Systems, by nature, has a very wide scope—extending all the way from vehicle sensor design to advanced traffic management algorithms. If you follow our conferences, transactions, magazine, ITS Now!, and our latest ITS Podcasts, you will see the wide breadth of topics that we cover. Because of this breadth, our conferences and events get a great mixture of researchers from different disciplines, making for lively discussions. narrowly focused. One of my goals is to continue to encourage the multi-disciplinary nature of our

activities program under the guidance of Brendan Morris. I am very much looking forward to see these activities evolve in the near future.

The recent growth and achievements show that our Society is on a good way to serve its members and to offer solutions for transportation demands of humanity. These goals can only be approached through a joint effort of a broad variety of experts. We are fortunate to have many of those in our society and even more fortunate that many individuals volunteer in our society as reviewers and editors for our conferences and journals, organizers of chapters, conferences, and meetings and as members in the society's self-organizing boards.

Indeed, I am deeply grateful to the numerous Society members who serve as reviewers, associate editors, editors, conference chairs, committee members, and officers, all of them offering their valuable time as volunteers! I'd like to recognize the effort of all the individuals that worked with me during my term as President, and in particular the members of the IEEE ITS Executive Committee and the Editors-in-Chief of our publications.

Being President was an honor and an exciting experience for me. Now, I am passing on the Presidency to Prof. Matthew Barth, our new President for 2014-2015. I know Matt from many years of successful work as member of our Board of Governors and as Vice President successfully managing our conference portfolio. As a personal note, I am delighted by his election. I am convinced that the Society will further flourish under his guidance.

Much success to you, Matt, and to our Society for a bright future!

Christoph Stiller  
Past President IEEE ITSS

ITS society, bringing it greater strength, diversity, and interest. Along with this, our membership will continue to grow for years to come. I am hopeful that we can exceed 2000 members by the end of my term in 2015.

Another key goal will be to encourage formation of more chapters and student branch chapters in our society. This has multiple benefits, including: 1) members can be better served by having local activities and contacts; 2) it will better engage our student members into the ITS field; 3) it should encourage better communication between society officers, chapter chairs, and members to solicit feedback and suggestions for improvements to our society.

I look forward to serving as your President over the next two years. We have an excellent set of society member volunteers who serve in many ways, including our Executive Committee, our Board of Governors, the various conference organizers, and last but-not-least, all our reviewers that guarantee the quality of our publications.

Christoph, our out-going president, has done an excellent job of leading our society forward. I hope to build on the momentum he and other past-presidents have created.

Sincerely,

Matt Barth  
President IEEE ITSS

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## 2013 Board of Governors Election Results

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Each year, the members of the Society elect five members to serve a three year term on the Board of Governors (BoG), the Society's governing body. The BoG consists of the fifteen elected members (five each year for a three-year term) and the officers of the Society.

The candidates for election are nominated by the Society's Nominations Committee. The chair of the Committee is designated in the Society's bylaws. This year, the chair was Alberto Broggi who was president in 2010-2011. IEEE has announced the results of the election for the Board of Governors. The following five candidates have been elected to a three year term beginning January 1, 2014.

Kazuya Takeda  
Nagoya University  
Japan

Meng Lu  
Dutch Institute for Advanced Logistics (Dinalog)  
The Netherlands

Jan Becker  
Robert Bosch, Stanford University  
USA

Danil Prokhorov  
Toyota Research Institute  
USA

Thomas Braunl  
The University of Western Australia  
Australia

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**IEEE ITS Outstanding Research Award  
IEEE ITS Outstanding Application Award  
IEEE ITS Institutional Lead Award**

*Call for Nominations*

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**Purpose and Selection Criteria**

The prestigious IEEE ITS Outstanding Research Award, IEEE ITS Outstanding Application Award, and IEEE ITS Lead Award are conferred annually to honor ITS researchers, practitioners, and research/development teams who have made significant contributions to research in ITS related fields (for ITS Research Award), developed and deployed successful ITS systems or implementations (for ITS Application Award), and demonstrated leadership in promoting ITS technologies (for ITS Institutional Lead Award). These awards have been established to recognize, promote, and publicize major research contributions, application innovations with real-world impact, and ITS institutional leadership.

**Nomination Materials**

Each nomination must consist of the following materials:

- (1) A 5-page summary statement providing sufficient detail for evaluation of the innovations and impact of the work.
- (2) At least 3 letters of recommendation from the recognized peer researchers, customers or users of the developed application, and organizations attesting to the work's significance and impact.

A dedicated selection committee will evaluate all qualified nominations for these IEEE ITS Awards. Awards will be announced in October 2014 at the ITSC 2014 conference in Qingdao, China, where the recipients will give featured presentations of their work.

Please email nominations before June 1, 2014 to ITSS Vice President for Membership at [Daniel.D.Zeng@ieee.org](mailto:Daniel.D.Zeng@ieee.org)

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## IEEE ITSS Best Ph.D. Dissertation Award

### *Call for Applications*

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#### **Application Materials**

Each application must consist of the following materials:

1. A doctoral dissertation written by the applicant in any language, no more than 18 months prior to the submission deadline.
2. A summary of the dissertation in English of up to 3 pages in length written by the Ph.D. candidate, highlighting the significance of the problem, the technical approach taken, application context and potential, and the scope of the dissertation.
3. Sample published paper(s) in English based on the dissertation written primarily by the Ph.D. candidate in scientific journals such as the IEEE Transactions on ITS or the IEEE ITS Magazine.
4. Listing of all publications by the applicant in the related field(s).
5. A letter of recommendation from the applicant's dissertation advisor that assesses the significance of the research, attests to the originality of the work, and comments on the engagement of the applicant in the ITS field and the IEEE ITS Society.

#### **Prize and Presentation**

The first place winner will receive USD 1,000. The second place prize winner will receive USD 500. Awards will be announced in October 2014 at the ITSC 2014 conference in Qingdao, China, where the recipients will give brief presentations of their work. Awardees' work will be featured in ITSS Transactions, ITS Magazine, and ITS Newsletter, when appropriate.

#### **Applications**

A dedicated selection committee will evaluate all qualified applications for the IEEE ITS Best Ph.D. Dissertation Awards and make selections. Please submit the application materials by email before June 20, 2014 to ITSS Vice President for Membership at [Daniel.D.Zeng@ieee.org](mailto:Daniel.D.Zeng@ieee.org).

Daniel Zeng  
VP for Membership

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## ITS Podcast

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# A new episode of the ITS Podcast has been published

*Please, circulate this!*

The main content of this new episode is a fresh interview to Professor Alberto Broggi, from University of Parma, in Italy, about the latest fantastic challenge VisLab has delivered to the amazement of the whole ITS research community: PROUD2013.

Professor Broggi, from VisLab, has collaborated with the ITS Podcast a couple of times in the past, including its pilot episode, where we talked about the Intercontinental Autonomous Driving Challenge they accomplished on the Summer of 2010, when they had a 100 days long autonomous driving experiment from Parma to the International Expo in Shanghai.

This time he has kindly hosted us today at his research centre in Parma to talk about PROUD2013, standing for Public ROad Urban Driverless-Car Test. Their autonomous car Braive has driven unmanned from the University Campus to the city town hall through a number of real world difficulties, merging into real traffic, with real pedestrians, etc.

We have also produced a news mini-section and a transportation in history section, this time around bicycles.

Please, check it out and feedback the show with your comments at the podcast website or at our social networking accounts: [LinkedIn](#), [Twitter \(@ITSPodcast\)](#), [Facebook](#), [Google+](#) or by email: [itsspodcast@gmail.com](mailto:itsspodcast@gmail.com)

[ITS Podcast Episode 9](#)

## ITS Podcast "Best Follower" Contest

*Please, circulate this!*

It has just started! Do you want a new i-pad? You can win it if you help us out by disseminating the ITS Podcast!

We are starting a new contest to find the "Best Follower" of this show. This is our way of thanking you, our listeners for helping to grow this podcast by spreading the word.



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# ITS Podcast

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The contest is just opened, and will be open until April 30. During this time period, we will determine who is the most active listener based on activities to inform others about ITS Podcast.

In order to be eligible for the contest, each entrant must send proof of his/her dissemination efforts to [itsspodcast@gmail.com](mailto:itsspodcast@gmail.com). All dissemination efforts will be taken into consideration but must be documented to be included in the contest. You can use your imagination. It's up to you if you want to go even beyond [LinkedIn](#), [Twitter \(@ITSPodcast\)](#), [Facebook](#), [Google+](#) Just send us proof to [itsspodcast@gmail.com](mailto:itsspodcast@gmail.com).

The contest winner will be announced on the May 2014 ITS Podcast episode, at a special edition on the first anniversary of the show.

So, don't waste another minute and start spreading the word around you! You will find this contest information in the ITS Podcast website at [itsp.cicei.com](http://itsp.cicei.com).

Thanks for your support and help!

Javier Sanchez-Medina  
EiC IEEE ITSS ITSPodcast  
[javier.sanchez.medina@ieee.org](mailto:javier.sanchez.medina@ieee.org)  
[itsspodcast@gmail.com](mailto:itsspodcast@gmail.com)

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## An IEEE Women in Engineering/ITSS Event

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Please join **Dr. Anya Petrovskaya**, recipient of the 2012 ITSS Ph.D. Best Dissertation Award, for a live chat on February 10, 2014 at 3 PM EST.

A research consultant at Stanford University, Dr. Petrovskaya will discuss her research field in robot reliable perception. She will also share her advice to future engineers.

You can view the broadcast and ask her questions, for example, about her career in science and engineering, her technical presentation, and what led her to study robotics.

The one-hour chat, supported in part by ITSS, and produced by the IEEE Women in Engineering Committee ([http://www.ieee.org/membership\\_services/membership/women/index.html](http://www.ieee.org/membership_services/membership/women/index.html)), can be found on USTREAM <http://www.ustream.tv/channel/anya-petrovskaya>

You can also see information about this chat on the WIE Facebook Page is <https://www.facebook.com/events/1376277652636832/>

Emily Sopensky, ITSS BOG member

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## Featured Article

### An Automated Truck Platoon within the Energy ITS Project

By Prof. Sadayuki Tsugawa. Meijo University, Nagoya, Japan

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**Background of the Project:** According to the statement by the Inter-government Panel on Climate Change (IPCC) in February, 2007, the global warming has been caused, and it is resulting in greenhouse gases, most of which is CO<sub>2</sub>. Since then, ITS (Intelligent Transport Systems)-related projects focusing on energy and environment in addition to safety have been started in the world, and one of the projects is the Energy ITS project initiated by Japanese Ministry of Economy, Trade and Industry in 2008. Currently, in Japan, the transportation sector consumes about 20 % of all the energy consumed in Japan, and the consumption by automobiles accounts for about 90 % of the transportation sector. The CO<sub>2</sub> emission from the transportation sector (222 M ton) accounts for 18 % of the whole emission from Japan (1,240 M ton), and 91 % of CO<sub>2</sub> of the transportation sector is emitted from automobiles. Automobiles, thus, are one cause of the global warming.

The project, conducted till 2013 for 5 years with the total budget of 4.4 billion yen, has two themes: an automated truck platoon and an evaluation method of effectiveness of ITS on energy saving, and here the automated truck platoon will be introduced.



Fig. 1. The automated platoon of 3 heavy trucks and a light truck.

**Automated Trucks:** The automated truck platoon developed in the project, as shown in Fig. 1, consists of 3 heavy (25 ton) trucks and a light truck, and currently drives at 80 km/h with the gap of 10 m and 4 m on a test truck. The functions of the platoon are lane keeping, speed control, collision avoidance, and gap keeping. Among these functions, the gap keeping function contributes to energy saving, and the other functions contribute to increase safety and to reduce drivers' workload. Figure 2 shows the configuration of a fully automated truck for the automated platoon. The resulting trucks are highly reliable, exhibiting redundancy in the sensing systems, the vehicle control ECU (electronic control unit), the communication system, and the actuators.

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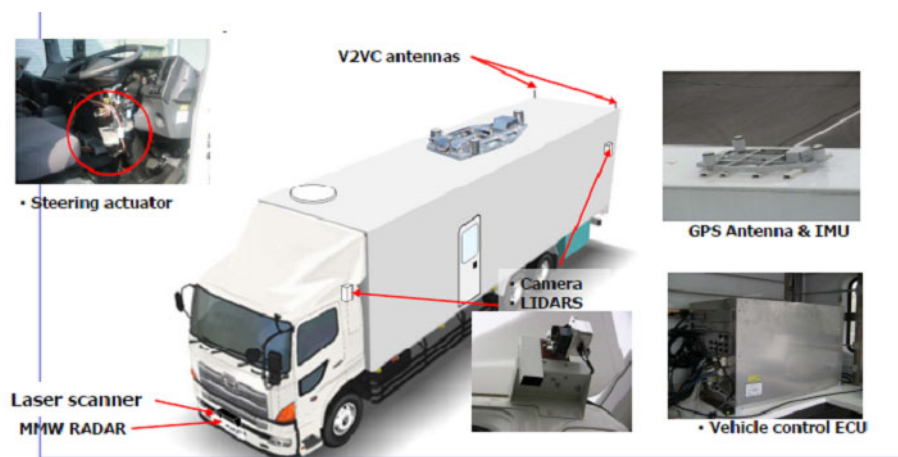


Fig. 2. Configuration of the automated truck.

Each truck is equipped with 2 machine vision units; one unit is attached at the front and the other is at the rear as shown in Fig. 2 for detection of the deviation of a truck from a lane marker and the relative direction of a truck against a lane maker. The deviation and the direction are for the lateral control. Each sensor looks downward and detects a lane marker immediately at the left hand side of a truck for robustness against light noise. Each truck has 76 GHz radar and a 2-dimensional lidar for obstacle detection on the first truck in the platoon, and for gap measurement on the following trucks. The use of two different sensors contributes to enhancing robustness. Since the sensing system is not enough for precise control of the gap keeping, the platoon employs vehicle to vehicle (V2V) communications. The communications use two media, 5.8 GHz DSRC and infrared, for robustness. Data of each truck are shared in real time among the trucks in the platoon and the communication unit with a period of 20 ms.

**Effectiveness on Energy Saving:** Platooning can contribute to energy saving in two aspects: the reduction of aerodynamic drag and the increase of the road capacity. In order to investigate the aerodynamic drag reduction of the automated truck platooning, computational fluid dynamic (CFD) simulation was conducted. Figure 3 shows the results when the trucks are driving at 80 km/h with the gap of 4 m. As shown in the top of Fig. 3, the air pressure behind each truck is low and as shown in the bottom of Fig. 3, the air velocity behind each truck is small. The CD value of the lead truck and the last truck decreases by more than 20 %, and that of the middle truck decreases by about 50 %. Since the aerodynamic drag is larger than the rolling resistance when trucks are driving at high speed, the fuel consumption of the platoon will decrease by about 15 % at high speed driving.

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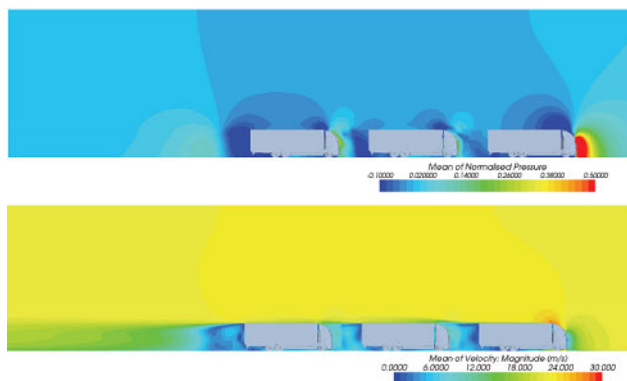


Fig. 3. CFD simulation results when the trucks are driving at 80 km/h with the gap of 4 m.

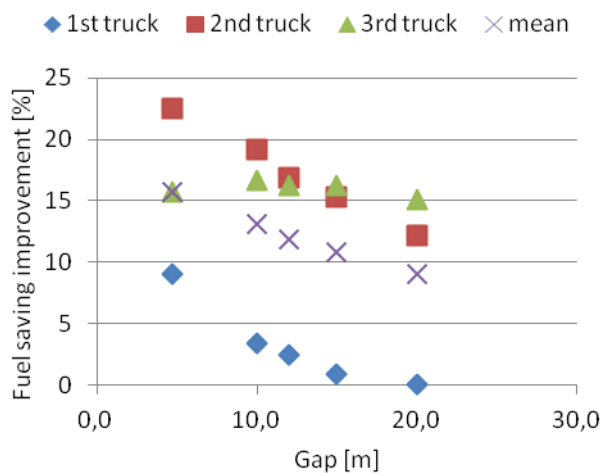


Fig. 4. Relationship between the fuel saving improvement and the gap in the platoon.

The fuel consumption was measured during the experiments on a test track under constant velocity conditions at 80 km/h (the gap was 10 m and 4.7 m). The trucks were empty-loaded. Figure 4 shows the results. The measurements indicate the mean energy saving is 13 % when 10 m gap and 18 % when 4.7 m gap. When the trucks are ordinarily loaded and drive at 80 km/h, the fuel saving will be 8 % with a 10 m gap, and 15 % with a 4 m gap.

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## Featured Article

### An Automated Truck Platoon within the Energy ITS Project

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The other theme of the project is to develop an evaluation method of effectiveness of ITS on CO<sub>2</sub> emission reduction, and a simulation study was conducted under this theme to evaluate the effectiveness of the platooning on expressways. The result shows that, for example, when the penetration of platooning of heavy trucks is 40 %, the CO<sub>2</sub> reduction along expressways will be 2.1 % when the gap is 10 m, and 4.8 % when the gap is 4 m.

**Conclusions:** An automated truck platoon, its technologies and the effectiveness on the energy saving have been introduced. For the introduction, not only legal and institutional issues but also technological issues including the reliability of both the hardware and software of the automated driving system must be solved.

The Energy ITS project was supported by the New Energy and Industrial Technology Development Organization (NEDO).

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# 2013 IEEE Intelligent Transportation Systems Conference – Report

## Future of Transport discussed in stately Dutch Heritage site

By: Bart van Arem, Hans van Lint, Andreas Hegyi, Pieter Leo

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Last October the TU Delft hosted the IEEE ITS congress in a Dutch heritage site the Kurhaus hotel in Scheveningen. This sixteenth edition with an astounding 506 participants, 635 submitted papers and 3 days of 81 technical sessions in 9 parallel tracks was a great success. It brought us researchers from around the globe presenting the newest insights in theory, simulation, models and data analysis all to do with the future of transport, Intelligent Transport Systems. For the TU Delft and the Netherlands this event was ideal to show the ITS world what it has to offer. This time around we also tried to incorporate conferencing 2.0 by adding the use of social media during the conference. By using live blogs during presentations and spreading information by using twitter we tried to reach a wider audience than only the conference participants. A few abstracts of the blogs:

### The 2013 ITCS conference takes time to celebrate at Tuesday evening’s Conference Banquet

Posted on 09/10/2013 by Aaron Lee



Daniel Topfer accepts the award for the best paper of the conference for his paper “Efficient scene understanding for intelligent vehicles using a part-based road representation”.

Participants of the ITSC 2013 conference were able to celebrate this year’s gathering and look forward to next year this evening at the Conference Banquet. Awards and presentations were scattered among a three-course meal, featuring a smoked salmon salad, a veal tenderloin and the highly anticipated Bombe of Chocolate.

### Watch out! Automated Obstacle Detection: Why? How? What?

Posted on 08/10/2013 by Jessica Aceves Flores



Pedestrian detection algorithm

Today’s technology allows for fully automated vehicles to drive around everywhere and under all environmental conditions. If so, why is it that fully automated vehicles are not (yet) commercially sold?

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## 2013 IEEE Intelligent Transportation Systems Conference – Report

### Future of Transport discussed in stately Dutch Heritage site

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The authors of the blogs were Manos Chaniotakis, Aaron Lee and Jessica Aceves Flores of the TU Delft and can be fully read on <http://transport.weblog.tudelft.nl/>

#### Sessions for all Modalities

This year's theme was focussed on ITS for all Transport modes resulting in special sessions and a broader audience. These sessions were split up into 4 to 6 presentation blocks of 10 minutes in which a specific subject within the field was elucidated. A great variety of subjects were addressed, all with great content, but if asked about some highlights; the starting plenary session with;

Ronald Adams (Rijkswaterstaat) “Bringing ITS to the next level”

Bob Denaro (ITS Consulting) “ITS - Connecting, and Extrapolating, the Dots”

Matthew G. Karlaftis (National Technical University of Athens) “ITS Data Analysis and Artificial Intelligence: Major Challenges, Unique Opportunities”

Were a great inspiration for us all. Furthermore the session about ITS transport in BRIC countries was an eye opener. The opportunities that arise in countries with an explosive traffic growth and an increasing economic wealth and need are subjects that are great to address. The presentations show that improvement on safety and environment are the real rising stars within these BRIC countries and the possibility to test in an unscathed environment are immense.

#### Ph.D. Event

A dinner for master and Ph.D. students participating the IEEE ITS Conference was organized on Monday, 7<sup>th</sup> of October 2013, at Het Wapen van Den Haag, a restaurant located in the city centre of The Hague. One hundred students from various universities attended the dinner. During the dinner, Peter Wieringa, vice-rector of TU Delft, gave a short speech about the challenges of doing a Ph.D., the role of Ph.D. students (and researchers in general) in society, and career paths for Ph.D. graduates. Also, after the first dish, students were asked to change seat, so as to make it possible for them to get to know as many other students as possible. The evaluation of the event, according to the participants, was very good. In particular, the participants appreciated the chance to interact with other students in an informal environment, without the presence of their peers.



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# 2013 IEEE Intelligent Transportation Systems Conference – Report

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### Sunday Workshops

The Sunday program initialized workshops for participants on varying fields in transport. The TU Delft, University of Birmingham, University of Las Vegas, Beijing Jiaotong University, Kai Korea all hosted one of these workshops in the following subjects Traffic Assignment, Electric Vehicles, Green Railway, Swarm Intelligence and Traffic Monitoring in Extreme Congestion. The interaction achieved by the hosts and the knowledge received by the participants created a great buzz for the opening on Sunday afternoon. We would like to thank and acknowledge all participating parties.

### Prize Winners

The papers that were received this year showed a tremendous amount of quality, and to select prize winners was a difficult task for the organization. That's why the following people deserve extra compliments for their great work in the past years and we hope to see more of them in the future. The papers were first split into different sections and then compared. The following two awards were meant for the congress.

### Best Conference Paper

**1. Efficient scene understanding for intelligent vehicles using a part-based road representation**

Daniel Töpfer, Jens Spehr, Jan Effertz, Christoph Stiller (Karlsruhe Institute of Technology)

**2. A cooperative system based variable speed limit control algorithm against jam waves - an extension of the specialist algorithm**

Andreas Hegyi, Bart Netten, Meng Wang, Wouter Schakel, Thomas Schreitner, Yufie Yuan, Bart van Arem, Tom Alkim (Delft University of Technology)

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# 2013 IEEE Intelligent Transportation Systems Conference – Report

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### Best Student Paper

#### 1. Monitoring the Railway Infrastructure: Detection of Surface Defects Using Wavelets

Maria Molodova, Zili Li, Alfredo Núñez and Rolf Dollevoet (Delft University of Technology)

#### 2. Analysis of Traffic Performance of a Ramp Metering Strategy Using Cooperative Vehicles

Riccardo Scarinci, Benjamin Heydecker, Andreas Hegyi (University College London)

#### 3. Automatic Change Detection and Incremental Updating for Accurate 3D Urban Cartography”

Ahmad Kamal Aijazi, Paul Checchin and Laurent Trassoudaine (Agence Nationale de la Recherche)

We would like to thank all participants, attendees and presenters for their effort during the congress. Without your help we would not have enjoyed the organisation as much as we did. We hope to see you all next year in Qingdao.





# Call for Papers



## 2014 IEEE Intelligent Vehicles Symposium Sponsored by the IEEE Intelligent Transportation Systems Society June 8 - 11, 2014, Dearborn, Michigan, USA

**THE INTELLIGENT VEHICLES SYMPOSIUM (IV'14)** is a premier annual forum sponsored by the **IEEE INTELLIGENT TRANSPORTATION SYSTEMS SOCIETY (ITSS)**. Researchers, 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 oral session and multiple poster sessions where all attendees can exchange ideas 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.

### 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
- Proximity Detection Technology
- Assistive Mobility Systems
- Proximity Awareness Technology
- 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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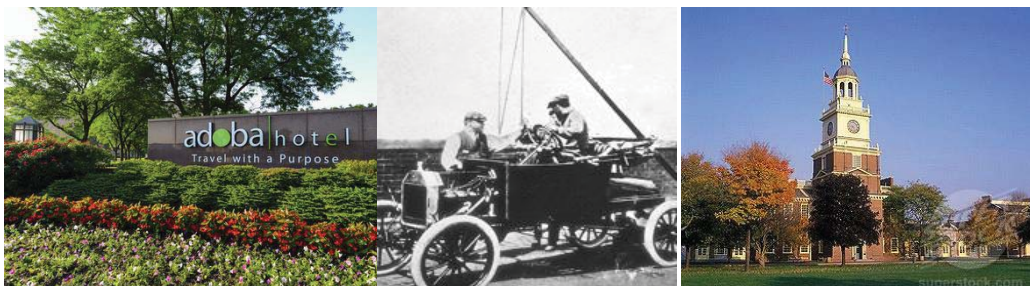
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**SPECIAL and TUTORIAL SESSIONS** are encouraged. Organizers should contact **Prof. Daniel J Dailey** at dan@uw.edu or **Prof. S. Tsugawa** at tsugawa@meijo-u.ac.jp.

### PAPER SUBMISSION

Manuscripts must be electronically submitted through the conference website [www.ieeeiv.net](http://www.ieeeiv.net). Submitted manuscripts should be at most six (6) pages in IEEE two-column format, including figures, tables, and references. Please use the templates at [Manuscript Templates for Conference Proceedings](#) available from the conference website to prepare your manuscript. All submissions MUST be in PDF format.

### IMPORTANT DATES

- Paper Submission Deadline : January 31, 2014 (sharp)
- Workshop Proposal Deadline : January 31, 2014 (extended)
- Notification of Acceptance : March 21, 2014 (extended)
- Open for final submission : March 22, 2014 (extended)
- Final Paper Submission : April 18, 2014 (extended)





## The 17th International IEEE Conference on Intelligent Transportation Systems

The IEEE Conference on Intelligent Transportation Systems is the annual flagship conference of the IEEE Intelligent Transportation Systems Society. IEEE ITSC 2014 welcomes articles in the field of Intelligent Transportation Systems, conveying new developments in theory, analytical and numerical simulation and modeling, experimentation, advanced deployment and case studies, results of laboratory or field operational tests. IEEE ITSC 2014 is organized by the State Key Laboratory of Management and Control for Complex Systems (SKL-MCCS) at the Institute of Automation, Chinese Academy of Sciences (CASIA).

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### Local Chair

Xinzhu Zhang  
Qingdao Municipal Government

### Topics

The technical areas include but are not limited to the following:

- Artificial Transportation Systems
- Advanced Public Transportation Management
- Ports, Waterways, Inland navigation, and Vessel Traffic Management
- Modeling, Simulation, and Control of Pedestrians and Cyclists
- Air, Road, and Rail Traffic Management
- ITS User services
- Emergency Management
- Transportation Networks
- Emissions, Noise, Environment
- Management of Exceptional Events: Incidents, Evacuation, Emergency Management
- Security Systems
- Safety Systems
- Driver and Traveler Support Systems
- Commercial Vehicle Operations
- Intelligent logistics
- Sensing and Intervening, Detectors and Actuators
- Data Management Systems
- Communication in ITS
- Cooperative Techniques and Systems
- Intelligent Vehicles
- Vision, and Environment Perception
- Electric Vehicle Transportation Systems
- Electronic Payment Systems
- Intelligent Techniques in ITS
- Traffic Theory for ITS
- Modeling, Control and Simulation
- Human Factors, Travel Behavior
- ITS Field Tests and Implementation

### Paper Submission

Complete manuscripts in PDF format must be electronically submitted for peer-review in IEEE standard format. Detailed submission instructions can be found through conference website.

### Important Dates

Please visit the conference website at <http://www.itsc2014.org/> for the deadlines.



IEEE ITSC 2014 will be held together with the 2014 IEEE International Conference on Service Operations and Logistics, and Informatics.





## Human Factors in Intelligent Vehicles

*Workshop Series at IEEE IV Conferences*

\*\*\*\*\*

### **3rd WORKSHOP ON HUMAN FACTORS IN INTELLIGENT VEHICLES**

[\(http://hfiv.lfe.mw.tum.de/2014/\)](http://hfiv.lfe.mw.tum.de/2014/)

**Sunday 8 June, Dearborn, Michigan, USA**

To be held at the **2014 IEEE Intelligent Vehicles Symposium, IV'14**

**June 8 - 11, 2014, Dearborn Michigan, USA**

[\(http://www.ieeeiv.net/\)](http://www.ieeeiv.net/)

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**SUBMISSION DEADLINE: February 15th, 2014**

### **AIM AND SCOPE**

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The IEEE HFIV Workshop to be collocated with the 2014 IEEE Intelligent Vehicles Symposium, to be held in the Dearborn, Michigan, USA, June 8-11, 2014, will be the third edition of its series. This proposal follows up the successful events previously held in Alcalá de Henares, Spain, during IV 2012, and Gold Coast, Australia, during IV 2013. The IEEE Workshop series on Human Factors in Intelligent Vehicles aims to foster discussion on issues related to the analysis of human factors in the design and evaluation of intelligent vehicles 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 drivers and their behavior towards improving driving performance while reducing road accidents as well as psycho and physical exhaustion still demands proper tools and approaches. Whereas the feasibility of incorporating new technology-driven functionalities 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 primary task of

driving the vehicle, as well as their impact on overall performance of transportation systems. 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 settings pose even more challenging issues.

Also, the information and functionalities that rely on new ways of communication have to be presented in a non-intrusive way while complying with specific design requirements. A system that guarantees efficiency of use, comfort and user satisfaction is inarguably an important contribution towards a more conscious driving behavior that directly results from the adoption of IV technologies.

## **TOPICS OF INTEREST**

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The HFIV'14 welcomes and encourages contributions reporting on original research, work under development and experiments of different fields related to Human Factors. 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 design and operation
- Modeling and simulation of driving performance
- Behavioral modeling and validation methodologies
- Tools and approaches to analyze human factors
- Ergonomics of traveler information systems
- Anthropometric layout of vehicular technical systems
- Mixed Reality
- Cross-Cultural Design
- Augmented Cognition
- User Experience and Usability
- Computer Aided Ergonomics Analysis
- Effects of in-vehicle systems on driver performance
- Tools and methodologies for usability assessment
- Input/Output modalities in system ergonomic design
- Learning, Anticipation, and Adaptation balance
- Driving Education and Training Methodologies

## **SUBMISSION INSTRUCTIONS AND PUBLICATION**

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Prospective authors are invited to submit contributions reporting on their current research and ideas that may potentially motivate active and fruitful discussion during the workshop. Each paper will be analyzed by the Workshop's International Program Committee according to quality of presentation, relevance and potential contributions. Accepted papers will be included in the workshop proceedings in a digital format and will be published in IEEE explore.

Authors must follow the IEEE Conference format in the preparation of their manuscripts of maximum 6 pages in standard IEEE double column PDF format via the Papercept system for peer-review by the workshop International Program Committee.

All accepted papers will imply that at least one of the co-authors attends the workshop to present the work. Authors will be given a certain time to orally present their papers and discussion will be actively motivated among attendees.

Camera-ready manuscripts must be sent due on April 11th, 2014.

Further and up-to-date information can be found on the official web site of the workshop at <http://hfiv.lfe.mw.tum.de/2014/>

### IMPORTANT DATES

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- Papers submission: **February 15, 2014.**
- Acceptance/rejection notification: **March 14, 2014.**
- Camera-ready version due: **April 11, 2014.**
- Workshop sessions: **June 8, 2014.**

### ORGANIZING COMMITTEE

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\* Dr. Cristina Olaverri Monreal Institute of Ergonomics, Faculty of Mechanical Engineering, Technische Universität München, Germany, [olaverri@lfe.mw.tum.de](mailto:olaverri@lfe.mw.tum.de)

\* Dr. Rosaldo Rossetti Department of Informatics Engineering, University of Porto, Portugal, [rossetti@fe.up.pt](mailto:rossetti@fe.up.pt)

## Conference Calendar

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*Massimo Bertozzi / Paolo Grisleri*

This section lists upcoming ITS-related conferences, workshops, or exhibits. Contributions are welcome; please send announcements to [itsconfs@ce.unipr.it](mailto:itsconfs@ce.unipr.it).

### 2014

January 10-11

8th International Conference on Intelligent Systems and Control (ISCO 2014)  
Coimbatore, Tamilnadu, India  
<http://www.kceisco.com>

February 12-13

6th ETSI ITS Workshop  
Berlin, Germany  
<http://www.etsi.org/ITSWorkshop>

April 8-10

SAE 2014 World Congress & Exhibition  
Detroit, Michigan, USA

April 15-18

6th Russian International Congress on ITS  
Moscow, Russia  
<http://www.erticonetwork.com/events/eventdetail/127/-/6th-russian-international-congress-on-its>

April 28-30

13th ITS Asia Pacific Forum 2014  
Auckland, New Zealand  
<http://www.itsasiapacificforum2014.co.nz/>

May 18-21

IEEE Vehicular Technology Conference: VTC2014-Spring  
Seoul, Korea  
<http://www.ieeevtc.org/vtc2014spring/>



May 21-23

19th International Conference on Urban Planning and Regional Development in the Information Society REALCORP 2014

Wien, Austria

<http://www.corp.at>

May 31-June 5

2014 IEEE International Conference on Robotics and Automation (ICRA 2014)

Hong Kong, China

<http://www.icra2014.com>

June 1-4

IEEE International Symposium on Industrial Electronics (ISIE 2014)

Istanbul, Turkey

Submission due by: January 12

<http://www.isie.boun.edu.tr>

June 5-6

European Conference on human centred design for Intelligent Transport Systems

Vienna, Austria

Submission due by: January 25

<http://conference2014.humanist-vce.eu>

June 8-11

The 2014 IEEE Intelligent Vehicles Symposium

Ypsilanti, MI, USA

Submission due by: January 10

<http://www.ieeeiv.net>

June 16-19

10th ITS European Congress - ITS Helsinki

Helsinki, Finland

Submission due by: April 11

<http://www.itsineurope.com/its10/>

June 23-28

18th International Forum on Advanced Microsystems for Automotive Applications (AMAA 2014)

Kaiserin Friedrich-House, Berlin (Germany)

<http://www.amaa.de/>

June 24-27

27th IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2014)

Columbus, OH, USA

<http://www.pamitc.org/cvpr14/>

September 7-11  
ITS World Congress 2014 - Detroit  
Detroit, MI, USA  
<http://itsworldcongress.org>

September 10-12  
International Conference on Mechatronic and Embedded Systems and Applications (MESA2014)  
Mechatronic and Embedded Technologies in Intelligent Transportation Systems (METITS)  
Senigallia, Italy  
Submission due by: March 8  
<http://mesa2014.org/>  
<http://mesa2014.org/it/symposia-mesa-13/>

September 14-18  
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014)  
Chicago, IL, USA  
Submission due by: February 5th  
<http://www.iros2014.org>

September 14-17  
IEEE Vehicular Technology Conference: VTC2014-Fall  
Vancouver, Canada  
Not yet open  
<http://www.ieeevtc.org/vtc2014fall/>

October 7-10  
2014 IEEE Multi-Conference on Systems and Control  
Antibes Congress Center, Nice/Antibes, France  
Submission due by: April 1  
<http://www.msc2014.org/>

November 20-21  
VISIGRAPP 2014: 9th International Joint Conference on Computer Vision, Imaging and Computer Graphic Applications  
<http://www.visigrapp.org/>

November 14-15  
ICTTE 2014 : International Conference on Traffic and Transportation Engineering  
Italy, Venice  
<https://www.waset.org/conferences/2014/italy/ictte/index.php>

November 20-21  
ICIAP 2014: International Conference on Image Analysis and Processing  
Capetown, South Africa  
<https://www.waset.org/conferences/2014/capetown/iciap/>

# Abstracts of forthcoming IEEE Transactions on ITS papers

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## A BURST EFFORT BROADCAST APPROACH OF MPEG-4 VIDEO TRANSMISSION FOR INTER-VEHICLE COMMUNICATION

CHU, YUNG-CHENG; HUANG, FRED NEN-FU

Efficient and real-time video broadcasting helps to increase driving safety and traveling fun for drivers. However, it is hard to structure vehicles into permanent network topologies and schedules to broadcast video streaming real-time in inter-vehicle communication (IVC) in a high-mobility vehicular environment. In order to achieve this, we have designed a burst effort broadcast (BEB) approach for IVC, which considers the challenges of high mobility and multi-hop broadcast, as well as the features of MPEG-4 video streams to adapt to highway scenarios. The BEB approach is distributed real-time without protocol overheads, and comprises a queuing procedure and scheduling scheme. The queuing procedure is of the pre-process of video transmission including the video shaping of groups of pictures (GOPs) and sequential re-ordering video frames. Based on the queuing procedure, a mobility-adaptive scheduler is applied to handle the broadcast and re-broadcast of the video stream. The concept of macroscopic broadcast is utilized to increase the broadcast performance and video perceived quality of service (PQoS) as well as to reduce the number of unnecessary redundant broadcasts. As an evaluation, the real MPEG-4 video was conducted in simulation and the broadcast performance was compared with another protocol by the metrics of peak signal to noise ratio (PSNR) and loss of video frames in different broadcasting scenarios, and the results were analyzed. The simulation proved that this approach is an efficient multi-hop broadcast solution that does indeed provide a realistic solution to promote a higher degree of video PQoS on highways.

## DESIGN AND EVALUATION OF CHARGING STATION SCHEDULING STRATEGIES FOR ELECTRIC VEHICLES

TIMPNER, JULIAN; WOLF, LARS

Electric vehicles still have relatively long and frequent charging cycles. Moreover, charging resources are typically limited and must therefore be used efficiently. The V-Charge project has the vision to provide a solution by combining autonomous valet parking with e-mobility, introducing improved parking and charging comfort. V-Charge proposes a solution for charging autonomous electric vehicles in parking places and efficiently using scarce charging resources, thus simplifying the life of the customer and increasing the feasibility of electric vehicles. For the management of parking lots and the charging resources, V-Charge provides a server back-end and a communication infrastructure. In this paper, we present our design of scheduling concepts for a coordinated charging strategy that is implemented by this back-end. Through intensive simulations we show that the V-Charge Server is able to efficiently handle realistic parking volume and performs well in fulfilling customer requirements, e.g., energy demand for the next driving tasks. Moreover, we evaluate the suitability of various scheduling strategies in different usage scenarios. For the simulation setup, real-world parking statistics obtained from Hamburg Airport and the City of Braunschweig are used.

## VALUATING SURFACE SURVEILLANCE TECHNOLOGY FOR COLLABORATIVE MULTIPLE-SPOT CONTROL OF AIRPORT DEPARTURE OPERATIONS

BURGAIN, PIERRICK; KIM, SANGHYUN; FERON, ERIC

Airport departure operations are a source of airline delays and passenger frustration. Excessive surface traffic is a cause of increased controller and pilot workload. It is also a source of increased emissions and delays, and does not yield improved runway throughput. Leveraging the extensive past research on airport departure management, this paper explores the environmental and safety benefits that improved surveillance technologies can bring in the context of gate- or spot-release strategies. The paper shows that improved surveillance technologies can yield 4% to 6% reduction of the average number of aircraft on the taxiway system during congested operations, and therefore emissions, in addition to the savings currently observed by implementing threshold-based metering strategies under evaluation at Boston Logan Airport and other busy airports during congested periods. These calculated benefits contrast sharply with our previous work, which relied on simplified airport ramp areas with a single departure spot, and where fewer environmental and economic benefits of advanced surface surveillance systems could be established. Our work is illustrated by its application to New-York LaGuardia and Seattle Tacoma airports.

## PERFORMANCE IMPROVED METHODS FOR COMMUNICATION-BASED TRAIN CONTROL (CBTC) SYSTEMS WITH RANDOM PACKET DROPS

BU, BING; YU, F. RICHARD; TANG (GUEST EDITOR ICIRT 2013), TAO

Communication-based train control (CBTC) systems use wireless local area networks (WLANs) to transmit train status and control commands. Since WLANs are not originally designed for applications with high mobility, random transmission delays and packet drops are inevitable, which could result in unnecessary traction, brake or even emergency brake of trains, loss of line capacity and passenger satisfaction. In this paper, we study the packet drops introduced by random transmission errors and handovers in CBTC systems, analyze the impact of random packet drops on the stability and performances of CBTC systems, and propose two novel schemes to improve the performances of CBTC systems. Unlike the existing works that only consider a single train and study the communication issues and train control issues separately, we model the system to control a group of trains as a networked control system (NCS) with packet drops in transmissions. Extensive field test and simulation results are presented. We show that our proposed schemes can provide less energy consumption, better riding comfortability, and higher line capacity compared to the existing scheme.

## EVOLVING BAYESIAN GRAPH FOR 3D VEHICLE MODEL BUILDING FROM VIDEO

GHOSH, NIRMALYA; BHANU, BIR

Traffic videos often capture slowly changing views of moving vehicles. These different and incrementally related views provide visual cues for 3D perception of the vehicles from 2D videos. This paper focuses on 3D model building of multiple vehicles with different shapes from a single generic 3D vehicle model by incrementally accumulating evidences in streaming traffic videos collected from a single static uncalibrated camera. When we do not know a priori the class of the vehicle to be seen next (true in a real traffic scenario), a flexible and evolvable Bayesian graphical

model (BGM) is required where the number of nodes, structure of links between them, and associated conditional probability distributions (CPDs) can change on-the-fly. Current BGMs fail to provide such online flexibility. We propose a novel BGM, called Structure Modifiable Adaptive Reason-building Temporal Bayesian Graph (SmartBG) that self-modifies in a data-driven way to model uncertainty propagation in 3D vehicle model building from 2D video features where only a subset of the 2D vehicle features is visible at any time-point, e.g., out of field-of-view (entry/exit), self-occlusion. Uncertainties are used as relative weights to fuse evidences and to compute overall reliability of the generated models. Results for different vehicles from several traffic videos and two different view-points demonstrate performance of the proposed method.

## **“NO FREE LUNCH” THEOREMS APPLIED TO THE CALIBRATION OF TRAFFIC SIMULATION MODELS**

CIUFFO, BIAGIO; PUNZO (GUEST EDITOR UNCERT. IN COMP. TRAFFIC MOD.), VINCENZO

In 1997, Wolpert and Macready have derived “No free lunch theorems for optimization”. They basically state that “the expected performance of any pair of optimization algorithms across all possible problems is identical”, that is to say that there is no algorithm that outperforms the others over the entire domain of problems. In other words, the choice of the most appropriate algorithm depends upon the specific problem under investigation and a certain algorithm, while providing good performance (both in terms of solution quality and convergence speed) on certain problems may reveal weak on certain others. This apparently straightforward concept is not always acknowledged by optimization practitioners. A typical example, in the field of traffic simulation, concerns the calibration of traffic models. In the present paper, a general method for verifying the robustness of a calibration procedure (suitable in general for any simulation optimization) is proposed based on a test with synthetic data. Main obstacle to this methodology is the significant computation time required by all the necessary simulations. For this reason, a Kriging approximation of the simulation model is proposed instead. The methodology is tested on a specific case study, where the effect on the optimization problem of different combinations of parameters, optimization algorithms, measures of goodness of fit and levels of noise in the data is also investigated. Results show the clear dependence between the performance of a calibration procedure and the case study under analysis and ascertain the need for global solutions in simulation optimization with traffic models.

## **MODELING AND SIMULATING A NARROW TILTING CAR USING ROBOTICS FORMALISM**

MAAKAROUN, SALIM; KHALIL, WISAMA; GAUTIER, MAXIME; CHEVREL, PHILIPPE

Modeling and simulation are fundamental tools to develop new urban vehicles. The aim of this work is to model and to simulate a narrow urban tilting car which should significantly decrease traffic congestion, pollution and parking problem. The structure of the vehicle contains closed kinematic chains. The modeling approach is based on the modified Denavit and Hartenberg description, commonly used in robotics, by considering the vehicle as a mobile robot composed of a multi-body poly-articulated system where the terminal links are the wheels. This description allows calculating automatically the symbolic expressions of the geometric, kinematic and dynamic models. A simulator is developed with Matlab/Simulink and the simulation of different scenarios is performed and analyzed.

## BANDWIDTH SYNCHRONIZATION UNDER PROGRESSION TIME UNCERTAINTY

LI, JING-QUAN

Deterministic progression time is generally assumed in bandwidth optimization models. However, progression time is cycle-by-cycle time-varying and generally longer than deterministic value. Progression time uncertainty has a considerable impact on the bandwidth that is obtained with deterministic data. In addition, we prove that there exist infinite optimal solutions in the MAXBAND model if a known optimal solution holds some properties. Different optimal solutions may have different sensitivity to progression time uncertainty. In this paper, we develop a two-phase approach: in the first phase, we solve the MAXBAND models with perturbation controlled by a parameter and generate a number of optimal or near-optimal plans; and in the second phase, we apply the Monte Carlo method to simulate random progression time, evaluate the generated plans, and rank them by the reliability. We also conduct extensive microscopic traffic simulation using VISSIM to evaluate delays and stops for certain optimal plans. Some observations are made.

## ALGEBRAIC CONNECTIVITY MAXIMIZATION FOR AIR TRANSPORTATION NETWORKS

WEI, PENG; SPIERS, GREGOIRE; SUN, DENG FENG

It is necessary to design a robust air transportation network. An experiment based on the real air transportation network is performed to show that the algebraic connectivity is a fair measure for network robustness. Therefore the goal of this work is to maximize the algebraic connectivity. Some researchers solve the maximization of the algebraic connectivity by choosing the weights for the edges in the graph. Others focus on the best way to add edges in a network in order to optimize the connectivity. In this research the authors formulate a new air transportation network model and show that the corresponding algebraic connectivity optimization problem is interesting because the two sub-problems of adding edges and choosing edge weights can not be treated separately. The new problem is formulated and exactly solved in small size air transportation network case. The authors also propose the approximation algorithm in order to achieve better efficiency. For large size networks, the semidefinite programming with cluster decomposition is first presented. Moreover, the algebraic connectivity maximization for directed networks is discussed. Simulations are performed for small scale case, large scale problem and directed network problem.

## IMPACT OF GATE ASSIGNMENT ON DEPARTURE METERING

KIM, SANGHYUN; FERON, ERIC

Departure metering reduces congestion by reducing the number of aircraft present on the airport surface at any time, while not starving the runway. Because some departing flights are held at gates, there is a possibility that arriving flights cannot access the gates and have to wait until the gates are cleared. This is called a gate conflict. Robust gate assignment is an assignment that minimizes gate conflicts by assigning gates to aircraft to maximize the time gap between two consecutive flights at the same gate; it makes gate assignment robust, but passengers may walk longer to transfer flights. In order to simulate the airport departure process, a queuing model is introduced. The model is calibrated and validated with actual data from New York La Guardia Airport (LGA) and a large U.S. hub airport. Then,

the model simulates the airport departure process with the current gate assignment and a robust gate assignment to assess the impact of gate assignment on departure metering. The results show that the robust gate assignment reduces the number of gate conflicts caused by departure metering compared to the current gate assignment. Therefore, robust gate assignment can be combined with departure metering to improve operations at congested airports with limited gate resources.

## SYMMETRICAL SURF AND ITS APPLICATIONS TO VEHICLE DETECTION AND VEHICLE MAKE AND MODEL RECOGNITION

HSIEH, JUNWEI; CHEN, LI-CHEN; CHEN, DUAN-YU

SURF (Speeded Up Robust Features) is a robust and useful feature detector for various vision-based applications but lacks the ability to detect symmetrical objects. This paper proposes a new symmetrical SURF descriptor to enrich the power of SURF to detect all possible symmetrical matching pairs through a mirroring transformation. A vehicle make-and-model recognition (MMR) application is then adopted to prove the practicability and feasibility of the method. To detect vehicles from the road, the proposed symmetrical descriptor is first applied to determine the ROI of each vehicle from the road without using any motion features. This scheme provides two advantages; there is no need of background subtraction and it is extremely efficient for real-time applications. Two MMR challenges, i.e., multiplicity and ambiguity problems, are then addressed. The multiplicity problem stems from one vehicle model often having different model shapes on the road. The ambiguity problem results from vehicles from different companies often sharing similar shapes. To address these two problems, a grid division scheme is proposed to separate a vehicle into several grids; different weak classifiers that are trained on these grids are then integrated to build a strong ensemble classifier. The HOG and SURF descriptors are adopted to train the weak classifiers through an SVM learning algorithm. Because of the rich representation power of the grid-based method and the high accuracy of vehicle detection, the ensemble classifier can accurately recognize each vehicle.

## USING DELAYED OBSERVATIONS FOR LONG-TERM VEHICLE TRACKING IN LARGE ENVIRONMENTS

SHAN, MAO; WORRALL, STEWART; MASSON, FAVIO; NEBOT (MAGAZINE GUEST EDITOR), EDUARDO

The tracking of vehicles over large areas with limited position observations is of significant importance in many industrial applications. This paper presents algorithms for long-term vehicle motion estimation based on a vehicle motion model that incorporates the properties of the working environment, and information collected by other mobile agents and fixed infrastructure collection points. The prediction algorithm provides long-term estimates of vehicle positions using speed and timing profiles built for a particular environment, and considering the probability of a vehicle stopping. A limited number of data collection points distributed around the field are used to update the estimates, with negative information (no communication) also used to improve the prediction. The paper introduces the concept of observation harvesting, a process in which peer-to-peer communication between vehicles allows egocentric position updates to be relayed among vehicles, and finally conveyed to the collection point for an improved position estimate. Positive and negative communication information is incorporated into the fusion stage, and a particle filter is used to incorporate the delayed observations harvested from vehicles in the field to improve the position estimates. The contributions of this work enable the optimization of fleet scheduling using discrete

observations. Experimental results from a typical large scale mining operation are presented to validate the algorithms.

## A BIBLIOMETRIC ANALYSIS OF THE INTELLIGENT TRANSPORTATION SYSTEMS RESEARCH BASED ON SCIENCE MAPPING

HERRERA-VIEDMA, ENRIQUE; COBO, MANUEL; OÑA, JUAN; CHICLANA, FRANCISCO; COLLOP, ANDY

In this paper we highlight the conceptual structure of the Intelligent Transportation Systems (ITS) research field from 1992-2011. To do that, an automatic approach for detecting and visualizing the hidden themes and their evolution across a consecutive span of years is applied. This automatic approach, based on co-word analysis, combines performance analysis and science mapping. To show the conceptual evolution of ITS, three consecutive periods have been defined: 1992-2001, 2001-2006, 2007-2011. The results allow us to identify which topics or themes have been studied by the ITS community, which have reached biggest impact, and which are the possible future trends. We have identified that the ITS research has been focused on six main thematic areas: VEHICLE-AND ROAD- TRACKING, DRIVER-BEHAVIOR-AND-SAFETY, SCENARIOS-SIMULATION, TRAFFIC-FLOW-AND-TRAFFIC MANAGEMENT, VEHICLE-CONTROL and VEHICLE NAVIGATION. We have also identified that the main topics that are being recently are the following: GPS, TRACKING, BEHAVIOR, SAFETY, FUZZY-CONTROL and NEURAL-NETWORK.

## A FRAMEWORK FOR ESTIMATING DRIVER DECISIONS NEAR INTERSECTIONS

GADEPALLY, VIJAY; KRISHNAMURTHY, ASHOK; OZGUNER, UMIT

We present a framework for the estimation of driver behavior at intersections, with applications to autonomous driving and vehicle safety. The framework is based on modeling the driver behavior and vehicle dynamics as a hybrid-state system, with driver decisions being modeled as a discrete state system, and the vehicle dynamics are modeled as a continuous state system. The proposed estimation method uses observable parameters to track the instantaneous continuous state, and estimates the most likely behavior of a driver given these observations. This paper describes a framework that encompasses the hybrid structure of vehicle-driver coupling and uses Hidden Markov Models to estimate driver behavior from filtered continuous observations. Such a method is suitable for scenarios that involve unknown decisions of other vehicles, such as lane changes or intersection access. Such a framework requires extensive data collection and the authors describe the procedure used in collecting and analyzing vehicle driving data. For illustration, the proposed hybrid architecture and driver behavior estimation techniques are trained and tested near intersections with exemplary results provided. Comparison is made between the proposed framework, simple classifiers, and naturalistic driver estimation. Obtained results show promise for using the Hybrid State System-Hidden Markov Model framework.



## DEVELOPMENT OF A CONTROL STRATEGY OF VARIABLE SPEED LIMITS TO REDUCE REAR-END COLLISION RISKS NEAR FREEWAY RECURRENT BOTTLENECKS

LI, ZHIBIN; LIU, PAN; WANG, WEI; XU, CHENGCHENG

The primary objective of this study was to develop a control strategy of variable speed limits (VSL) to reduce the rear-end collision risks near freeway recurrent bottlenecks. The risks of rear-end collisions were estimated using a crash risk prediction model developed specifically for the rear-end collisions at freeway bottleneck areas. The effects of the VSL control strategy were evaluated using the cell transmission model (CTM). Several control factors were tested, including the start-up threshold of collision likelihood, the target speed limit, the speed change rate, and the speed difference between adjacent links. The genetic algorithm was used for optimizing critical control factors. For the high demand scenario, the proposed control strategy used 25% of the maximum collision likelihood for the start-up threshold, 35 mph for the target speed limit, 10 mph per 30 s for the speed change rate, and 10 mph for the speed difference between different links. For the moderate demand scenario, the strategy used 20% of the maximum collision likelihood for the start-up threshold, 40 mph for the target speed limit, 15 mph per 30 s for the speed change rate, and 10 mph for the speed difference between different links. The results of comparative analyses suggested that the proposed control strategy outperformed other strategies in reducing the rear-end collision risks near freeway recurrent bottlenecks. With the proposed control strategy, the VSL control reduced the rear-end crash potential by 69.84% for the high demand scenario, and 81.81% for the moderate demand scenario.

## NEGATIVE BINOMIAL ADDITIVE MODELS FOR SHORT-TERM TRAFFIC FLOW FORECASTING IN URBAN AREAS

DARAGHMI, YOUSEF; YI, CHIH WEI; CHIANG, TSUN-CHIEH

Parallel, coordinated and network-wide traffic management requires accurate and efficient traffic forecasting models to support online, realtime and proactive dynamic control. Forecast accuracy is impacted by a critical characteristic of traffic flow that is overdispersion. Efficiency depends on the time complexity of forecasting algorithms. Therefore, this paper proposes a novel spatiotemporal multivariate forecasting model that is based on the Negative Binomial Additive Models (NBAMs). Negative Binomial is utilized to handle overdispersion and Additive models are used to efficiently smooth nonlinear spatial and temporal variables. To evaluate the model, it is applied to real-world data collected from Taipei city and compared with other forecasting models. The results indicate that the proposed model is an accurate and efficient approach in forecasting traffic flow in urban context where flow is overdispersed, autocorrelated, and influenced by upstream and downstream roads as well as the daily seasonal patterns that are: low, moderate and high traffic seasons.

## ANALYSIS OF GNSS PERFORMANCE INDEX USING FEATURE POINTS OF SKY-VIEW IMAGE

HONG, WOON-KI; CHOI, KWANGSIK; LEE, EUNSUNG; IM, SUNGHYUCK; HEO, MOONBEOM

When the Sky-View Factor(SVF) is used to predict positioning performance with GNSS, it is easy to use the SVF as a performance index without a specific database as is used for topographic maps, not only in open-sky land, but also in regions where there are many tall buildings. However, conventional SVF is only able to express the degree of

openness of the sky as a ratio, and it is limited to being used as a performance index for positioning that uses GNSS. When conventional SVF is used in a land transport environment, the predicted value for positioning performance using GNSS is often not consistent with the actual positioning error, but when Sky-View based DOP(SVDOP) is applied, we confirmed that it was substantially close to the actual positioning error. This confirms our expectation that utilization of the proposed method in land transport environments will make analysis easier than that with the utilization of SVF alone. In this paper SVDOP is calculated with real GPS data and the usefulness is validated by comparison with conventional SVF and DOP.

## RESEARCH ON A DSRC BASED REAR-END COLLISION WARNING MODEL

XIANG, XUEHAI; QIN, WENHU; XIANG, BINFU

DSRC (Dedicated Short-Range Communication) is an emerging technology that allows vehicles to communicate with each other. The rear-end collision warning system based on DSRC has its unique advantages. However, there are problems (e.g. high rates of false alarms and missing alarms in emergency warnings) in the system due to uncertain measurement errors. In this paper, we propose to address the problems by establishing a robust rear-end collision warning model without using expensive high-end devices. Simulations have shown that high rates (up to 56%) of missing alarms occur in the Vehicle Kinematics (VK) model, as well as false alarms (most of which exceed 70%) in the Vehicle Kinematics with Maximum Compensation (VK-MC) model. Pertaining to these rates, a novel model based on neural network (NN) approach is implemented. Through training and validation, the NN model is able to provide emergency warnings with an improved performance of false alarm probability under 20%, and the missing alarm probability under 10% for all test cases.

## OPTIMIZATION ON MULTI-TRAIN OPERATION IN SUBWAY SYSTEM

SU, SHUAI; TANG (GUEST EDITOR ICIRT 2013), TAO; LI, XIANG; GAO, ZIYOU

Energy efficiency is paid more and more attention in railway system for reducing the cost of operation company and the emission to the environment. In subway systems, the optimizations on timetable and driving strategy are two important and closely dependent parts of energy-efficient operation. The former regulates the fleet size and the trip time at interstations, and the latter determines the control sequences of traction and braking force during the trip. Most conventional research optimized the timetable and the driving strategy separately such that the global optimality cannot be achieved. In this paper, we analyze the hierarchy of energy-efficient train operation and then propose an integrated algorithm to generate the globally optimal operation schedule, which can get a better energy-saving performance. Within the criteria of meeting the passenger demand, the integrated energy-efficient algorithm can simultaneously obtain the optimal timetable and driving strategy for trains, which realizes the combination of the high-level transportation management and the low-level train operation control. The simulation results based on the Beijing Yizhuang subway line illustrate that the integrated algorithm can averagely achieve 24.0% energy reduction for one day. In addition, the computation time is within 2 seconds, which is short enough to be applied for real-time control system.

## IMPROVING GROUP TRANSIT SCHEMES TO MINIMIZE NEGATIVE EFFECTS OF MARITIME PIRACY

VANEK, ONDREJ; HRSTKA, ONDREJ; PECHOUCEK, MICHAL

Contemporary maritime piracy around the Horn of Africa presents a serious threat to the global shipping industry. A number of countermeasures was deployed to minimize the probability of a successful ship hijack, one of them being the establishment of the International Recommended Transit Corridor (IRTC). Currently, all ships transiting the Gulf of Aden are recommended to follow the IRTC and take part in group transit schemes - prescribed fixed schedules stating a time of arrival to the beginning of the corridor and a speed at which to sail through the corridor. We provide number of contributions that improve the group transit schemes: we formalize the grouping problem, we design an efficient algorithm able to compute optimal fixed group transit schemes with respect to the distribution of ships' speeds, we provide a real-world dataset with speeds of ships transiting the IRTC, we compare the optimal fixed schedules to the currently deployed schedule and quantify possible savings. Additionally, we propose on-demand group transit schemes - customized schedules for a group of arriving ships - that take into account speeds, risk aversion and actual positions of arriving ships. We formulate the problem of the optimal on-demand grouping as a bi-objective mixed integer program, and we compute a set of Pareto optimal solutions. We evaluate the scalability of the approach, the structure of the solution and quantify an improvement over the current group transit scheme with respect to the number of ships grouped as well as the time saved.

## COMPACT CONFIGURATION OF AIRCRAFT FLOWS AT INTERSECTIONS

HUANG, SHIMENG; FERON, ERIC; REED, GREGORY; MAO, ZHI-HONG

This paper proposes a compact configuration of aircraft flows at intersections. The goal is to achieve higher capacity of the airspace, allowing more aircraft to fly safely through a fixed region. Intersections of aircraft flows can be considered as basic building blocks for air traffic networks, and traffic networks can be designed through finding optimal arrangements of intersections whose conflict zones do not overlap. A conflict zone is defined as a minimal circular area centered at the intersection of two flows which allows aircraft approaching the intersections to resolve conflict completely within the conflict zone. This paper derives the relationship between the size of a conflict zone and the intersection angle of the two flows. Such a relationship guides the choice of the most compact configuration for intersecting aircraft flows. An example involving multiple converging flows of aircraft demonstrates the efficiency of the proposed configuration of intersections: The result of conflict resolution shows a greatly reduced traffic complexity. Therefore, our study provides a potential solution to increase airspace capacity.

## A MULTI-LEVEL MODELING OF TRAFFIC DYNAMIC

KUMAR, PUSHPENDRA; MERZOUKI, ROCHDI; CONRARD, BLAISE; COELEN, VINCENT; OULD-BOUAMAMA, BELKACEM

Nowadays, the traffic management is becoming more important to achieve the goal of sustainable transport and a good traffic model can describe the traffic behavior efficiently. The traffic models can be classified based on the level of details as sub-microscopic level model, microscopic level model, mesoscopic level model and macroscopic level

model. In this paper, we provide review of all the four (sub-micro, micro, meso and macro) types of models, then we propose a multi-level model of traffic, which combines sub-microscopic, microscopic and macroscopic levels of traffic model. In this work, we do not consider mesoscopic level model. At submicroscopic level, we develop bond graph model of a four wheeled vehicle considering the longitudinal, lateral, yaw and actuator dynamics. At microscopic level, we develop car-following model based on virtual inter-connection between the sub-microscopic bond graph models of vehicles. Then, at macroscopic level, we deduce macroscopic variables (average speed, density and flow) from the sub-microscopic and microscopic models. Having a multi-level model of traffic allows combining two properties of modeling simulation, one in real-time mode at microscopic and sub-microscopic levels and the other at offline mode at macroscopic level. Thus, the whole supervision of the road traffic can be performed. Finally, the multi-level model of traffic is validated on a real-time simulator of vehicle dynamic, based on experimental measurements acquired from Intelligent Autonomous Vehicles (IAVs). Also, real experiments on IAVs are performed to validate the model.

## ITS FOR SUSTAINABLE MOBILITY: A SURVEY ON APPLICATIONS AND IMPACT ASSESSMENT TOOLS

M. D'OREY, PEDRO; FERREIRA, MICHEL

**Abstract**—Road transportation is one of the main sources of greenhouse gas emissions, which lead to global warming and climate change. Promoting the decarbonization of the sector and more efficient and greener transport, is a challenging task that can be achieved namely by Intelligent Transportation Systems enabled by vehicular communications. In this paper we briefly present how mobility players and enablers (driver, vehicle and road network) influence fuel consumption and pollutant emissions. Furthermore, this survey paper details how different intelligent transportation systems, ranging from eco-routing to intelligent intersection management, can lead to sustainable mobility by promoting a more efficient vehicle usage and enhanced efficiency on road network utilization. Results shown that ITS has the potential to considerably reduce fuel consumption and pollutant emissions namely by smoothing the traffic flow, reducing the number of start-stops and reducing the total travel distance. Besides, we analyze the two main evaluation methods of green transportation system: field operational tests or simulation-based evaluations. We give special emphasis to simulation-based assessment of green ITS measures, namely by detailing the necessary models and their interactions. Finally, we propose a number of recommendations and future research directions.

## HYBRID COMMUNICATION PROTOCOLS AND CONTROL ALGORITHMS FOR NEXTGEN AIRCRAFT ARRIVALS

PARK, PANGUN; KHADILKAR, HARSHAD; BALAKRISHNAN, HAMSA; TOMLIN, CLAIRE

Capacity constraints imposed by current air traffic management technologies and protocols could severely limit the performance of the Next Generation Air Transportation System (NextGen). A fundamental design decision in the development of this system is the level of decentralization that balances system safety and efficiency. A new surveillance technology called Automatic Dependent Surveillance-Broadcast (ADS-B) can potentially be used to shift air traffic control to a more distributed architecture; however, channel variations and interference with existing secondary radar replies can affect ADS-B systems. This paper presents a framework for managing arrivals at an airport using a hybrid centralized/distributed algorithm for communication and control. The algorithm combines centralized

control in congested regions with distributed control in lower traffic density regions. The hybrid algorithm is evaluated through realistic simulations of operations around a major airport. The proposed strategy is shown to significantly improve air traffic control performance under various operating conditions, by adapting to the underlying communication, navigation and surveillance systems. The performance of the proposed strategy is found to be comparable to fully centralized strategies, despite requiring significantly less ground infrastructure.

## AN AGENT-BASED MICROSCOPIC PEDESTRIAN FLOW SIMULATION MODEL FOR PEDESTRIAN TRAFFIC PROBLEMS

LIU, S.B.; LO, S.M.; MA, JIAN; WANG, W.L.

Guaranteeing a safe, efficient and comfortable traveling system for pedestrians is one of the most important aspects of an intelligent transportation system. The microscopic simulation of pedestrian flow attracts increasing research attention in recent years since a reliable simulation model for pedestrian flow may greatly benefit engineers and operators in mass transportation management as well as designers and planners in urban planning and architecture. This paper introduces CityFlow, an agent-based microscopic pedestrian flow simulation model. The building floor plan in the model is represented by a continuous space constructed in a network approach, and each pedestrian is regarded as a self-adapted agent. Agent movement is implemented in a utility maximization approach by considering various human behaviors. The influences of parameters in the model on the simulation results are investigated. Typical pedestrian flow phenomena, including the unidirectional and bidirectional flow in a corridor as well as the flow through bottlenecks, are simulated. The simulation results are further compared with empirical study results. The comparison reveals that the model can approach the density–speed fundamental diagrams as well as the empirical flow rates at bottlenecks within acceptable system dimensions. The simulation results of the bidirectional pedestrian flow also show that the model can reproduce the lane formation phenomenon.

## OVERCOMING DROWSINESS BY INDUCING CARDIO-RESPIRATORY PHASE SYNCHRONIZATION

TAKAHASHI, ISSEY; TAKAISHI, TETSUO; YOKOYAMA, KIYOKO

Drowsiness is one of the major factors leading to car accidents. Many automobile companies and institutions have been studying ways to monitor drowsiness and keep drivers awake. When drowsiness is detected during driving, audible sound, vibrations or messages on a display are generally used to warn the driver to concentrate on driving or to take a rest. These methods help to prevent drowsiness-related crashes to some extent, but for greater safety, methods must be developed to physiologically overcome drowsiness. The key to overcoming drowsiness is to keep the body constantly supplied with oxygen. We focused on cardio-respiratory phase synchronization (CRPS) to recover from oxygen de-saturation during drowsiness. This study found it possible to induce CRPS by paced breathing (PB) using pulse sound, which synchronized with heartbeats. The experiment results showed SpO<sub>2</sub> measured from forehead increased during this PB. The increase of SpO<sub>2</sub> was larger than that of yawns, deep breathing, or a period of drowsiness reduced spontaneously. In conclusion, inducing CRPS by PB using pulse sound synchronized with the heartbeat has the potential to reduce drowsiness physiologically.

## REVERSING THE GENERAL ONE-TRAILER-SYSTEM: ASYMPTOTIC CURVATURE STABILIZATION AND PATH TRACKING

WERLING, MORITZ; REINISCH, PHILIPP; HEIDINGSFELD, MICHAEL; GRESSER, KLAUS

Backing up a trailer can be a challenge, especially for inexperienced recreational drivers. We therefore develop two feedback controllers which support the driver with automatic steering inputs in various situations. Based on the kinematics of the general one-trailer-system, we first derive an input/output-linearizing control law that asymptotically stabilizes a given curvature for the trailer. This enables the driver to directly steer the trailer, e. g. by means of a turning knob, such that the trailer will automatically be prevented from jackknifing. The control task is then modified and solved so that the vehicle can also take over the complete stabilization task along given paths. In combination with a path planning algorithm, this enables e. g. automated parallel parking. The complete system is implemented on a rapid prototyping environment and evaluated in real-world scenarios.

## INTELLIGENT TRIP MODELING FOR PREDICTION OF ORIGIN-DESTINATION TRAVELING SPEED PROFILE.

PARK, JUNGME; MURPHEY, YI; MCGEE, RYAN; KRISTINSSON, JOHANNES; KUANG, MIN; PHILLIPS, ANTHONY

Accurate prediction of the traffic information in real time such as flow, density, speed, and travel time has important applications in many areas including intelligent traffic control systems, optimizing vehicle operations, and the routing selection for individual drivers on the road. This is also a challenging problem due to dynamic changes of traffic states by many uncertain factors along a traveling route. In this paper, we present an Intelligent Trip Modeling System (ITMS) that was developed using machine learning to predict the traveling speed profile for a selected route based on the traffic information available at the trip starting time. The ITMS contains neural networks to predict short-term traffic speed based on traveling day of the week, the traffic congestion levels at the sensor locations along the route, and the traveling time and distances to reach individual sensor locations. The ITMS was trained and evaluated by using ten months of traffic data provided by California PeMS along a California Interstate I-405 route that is 26 miles long and contains 52 traffic sensors. The ITMS was also evaluated by the traffic data acquired from a 32-mile long freeway section in the state of Michigan. Experimental results show that the proposed system, ITMS, has the capability of providing accurate predictions of dynamic traffic changes and traveling speed at the beginning of a trip and, can generalize well to prediction of speed profiles on the freeway routes other than the routes the system was trained on.

## A PARTICLE BASED SOLUTION FOR MODELING AND TRACKING DYNAMIC DIGITAL ELEVATION MAPS

DANESCU, RADU; NEDEVSCHI, SERGIU

Digital elevation maps are simple yet powerful representations of complex 3D environments. These maps can be built and updated using various sensors and sensorial data processing algorithms. This paper describes a novel approach for modeling the dynamic 3D driving environment, the particle-based dynamic elevation map, each cell in this map having, besides height, a probability distribution of speed in order to correctly describe moving obstacles. The

dynamic elevation map is represented by a population of particles, each particle having a position, a height and a speed. Particles move from one cell to another based on their speed vectors, and they are created, multiplied or destroyed using an importance-resampling mechanism. The importance-resampling mechanism is driven by the measurement data provided by a stereovision sensor. The proposed model is highly descriptive for the driving environment, as it can easily provide an estimation of the height, speed and occupancy of each cell in the grid. The system was proven robust and accurate in real driving scenarios, by comparison with ground truth data.

## MODELING MANDATORY LANE CHANGING USING BAYES CLASSIFIER AND DECISION TREES

HOU, YI; EDARA, PRAVEEN; SUN, CARLOS

A lane changing assistance system that advises drivers of safe gaps for making mandatory lane changes at lane drops is developed. Bayes Classifier and Decision Tree methods were applied to model lane changes. Detailed vehicle trajectory data from the Next Generation Simulation (NGSIM) dataset were used for model development (US Highway 101) and testing (Interstate 80). The model predicts driver decisions on whether to merge or not as a function of certain input variables. The best results were obtained when both Bayes and Decision Tree classifiers were combined into a single classifier using a majority voting principle. The prediction accuracy was 94.3% for non-merge events and 79.3% for merge events. In a lane change assistance system, the accuracy of non-merge events is more critical than merge events. Misclassifying a non-merge as a merge event could result in a traffic crash while misclassifying a merge event as a non-merge event would only result in a lost opportunity to merge. Sensitivity analysis performed by assigning higher misclassification cost for non-merge events resulted in even higher accuracy for non-merge events but lower accuracy for merge events.

## RAIL COMPONENT DETECTION, OPTIMIZATION AND ASSESSMENT FOR AUTOMATIC RAIL TRACK INSPECTION

LI, YING; TRINH, HOANG; HAAS, NORMAN; OTTO, CHARLES; PANKANTI, SHARATH

In this paper, we present a real-time automatic vision-based rail inspection system, which perform inspections at 16 km/h with a frame rate of 20 fps. The system robustly detects important rail components such as ties, tie plates and anchors with high accuracy and efficiency. To achieve this goal, we first develop a set of image and video analytics, then propose a novel global optimization framework to combine evidence from multiple cameras, GPS (Global Positioning System) and DMI (Distance Measurement Instrument) to further improve the detection performance. Moreover, as anchor is an important type of rail fastener, we have thus advanced the effort to detect anchor exceptions, which includes assessing the anchor conditions at tie level and identifying anchor pattern exceptions at compliance level. Quantitative analysis performed on a large video data set captured with different track and lighting conditions as well as on a real-time field test, have demonstrated very encouraging performance on both rail component detection and anchor exception detection. Specifically, an average of 94.67% precision and 93% recall rate has been achieved on detecting all three rail components, and a 100% of detection rate is achieved for compliance-level anchor exception with 3 false positives per hour. To our best knowledge, our system is the first to address and solve both component and exception detection problems in this rail inspection area.

## ENERGY SUSTAINABLE TRAFFIC SIGNAL TIMINGS FOR A CONGESTED ROAD NETWORK WITH HETEROGENEOUS USERS

GE, XIAO-YAN; LI, ZHI-CHUN; LAM, W.H.K.; CHOI, KEECHOO

This paper proposes a novel model to address the energy efficient traffic signal timing problem for a congested road network with heterogeneous users. In the proposed model, two types of agents, namely the authority and road users, are considered together with interaction between traffic signal settings and energy policy (e.g. fuel surcharges). To model the route choice behavior of heterogeneous users, a multi-class stochastic traffic network equilibrium problem that considers vehicle delays at signalized intersections and travel demand elasticity is described and formulated as a variational inequality formulation. The authority aims to maximize social welfare of the transportation system by optimizing the traffic signal timings and fuel surcharges. A simulated annealing based solution algorithm is developed to solve the proposed model. The findings show that the implementation of the fuel surcharge policy can cause spatial and social inequity issues.

## ENERGY-EFFICIENT LOCOMOTIVE OPERATION FOR CHINA MAINLINE RAILWAYS BY FUZZY PREDICTIVE CONTROL

BAI, YUN; HO, TIN KIN; MAO, BAOHUA; DING, YONG; CHEN, SHAO KUAN

With the increasing energy consumption in China mainline railways amid the worldwide carbon emission concerns, the need for energy-efficient locomotive operation becomes urging. Locomotive operation is directly linked to speed limits imposed by the train ahead through signaling. In China mainline railway, speed limits for locomotive operation changes frequently because of relatively short headway in a highly congested network. Whenever speed limit changes, the locomotive operation must be determined again quickly to adapt to the new speed limit. As a result, the energy-efficient locomotive operation is a real-time optimization problem with time-varying constraints, in which the trade-off between solution optimality and computational time is essential but it has not been considered adequately in previous studies. This study develops a fuzzy predictive control approach, continuously providing locomotive operation instructions, with respect to the prevailing speed limits, to reduce energy consumption of train movement. The proposed approach is implemented in an on-board decision support system to assist drivers. The system is tested on the Ning'xi line in China and the results indicate that energy consumption on train operation is reduced by 4% while the computational requirement satisfies the demand of real-time solutions. Extensive simulations show the proposed approach is able to provide sufficient solution optimality in reasonable computational time under different operation settings.

## A PRACTICAL ROADSIDE CAMERA CALIBRATION METHOD BASED ON LEAST SQUARES OPTIMIZATION

ZHENG, YUAN; PENG, SILONG

In this paper, we propose a more practical and accurate method for calibrating roadside camera used in traffic surveillance systems. Considering the characteristics of the traffic scenes, we propose a minimum calibration condition that consists of two vanishing points and a vanishing line, which can be easily satisfied in most traffic scenes;



based on the minimum calibration condition, we provide a calibration method to estimate camera intrinsic parameters and rotation angles, which employs the least squares optimization instead of closed-form computation. Compared with the existing calibration methods, our method is suitable for more traffic scenes and is able to accurately determine more camera parameters including the principal point. By making full use of video information, the multiple observations of the vanishing points are available from different objects. For more accurate calibration, we present a dynamic calibration method using these observations to correct camera parameters. As for the estimation of camera translation vector, known lengths in the road or known heights above the road are exploited. The experimental results on synthetic data and real traffic images demonstrate the accuracy, robustness and practicability of the proposed calibration method.

## AGENT-BASED SIMULATION AND OPTIMIZATION OF URBAN TRANSIT SYSTEM

ZHANG, GUANGZHI; ZHANG, HAN; LI, LEFEI; DAI, CHENXU

To better solve the passenger assignment problem, which is a sub-problem of the transit network optimization problem, we build an Artificial Urban Transit System (AUTS) and propose a new Day-to-Day Learning Mechanism to describe passengers' route and departure time choice behaviors. With the support of AUTS to handle the lower level assignment problem, we are able to solve the upper level transit network design problem. Comparing with other bi-level models, our approach better accommodates passengers' dynamic learning behavior and their heterogeneity. Based on AUTS, we solved the frequency optimization problem. We also did some numerical experiments on AUTS and discovered some interesting issues on the capacity of public transportation system and passengers' heterogeneity.

## COMMUTER ROUTE OPTIMIZED ENERGY MANAGEMENT OF HYBRID ELECTRIC VEHICLES

LARSSON, VIKTOR; JOHANNESSON MÅRDH, LARS; EGARDT, BO; KARLSSON, STEN

Optimal energy management of hybrid electric vehicles requires a priori information regarding future driving conditions; the acquisition and processing of this information is nevertheless often neglected in academic research. This paper introduces a commuter route optimized energy management system, where the bulk of the computations are performed on a server. The idea is to identify commuter routes from historical driving data using hierarchical agglomerative clustering and then precompute an optimal energy management strategy with Dynamic Programming; the obtained solution can then be transmitted to the vehicle in the form of a look-up-table. To investigate the potential of such a system, a simulation study is performed using a detailed vehicle model implemented in the Autonomie simulation environment for Matlab/Simulink. The simulation results for a plug-in hybrid electric vehicle indicate that the average fuel consumption along the commuter route(s) can be reduced by 4-9% and battery usage by 10-15%

## EASISEE: REAL-TIME VEHICLE CLASSIFICATION AND COUNTING VIA LOW-COST COLLABORATIVE SENSING

WANG, RUI; ZHANG, LEI; XIAO, KEJIANG; SUN, RONGLI; CUI, LI

In the field of traffic information acquisition, one pervasive solution is to use wireless sensor networks to realize vehicle classification and counting. By adopting heterogeneous sensors in a wireless sensor network, we can explore the potential of using complementary physical information to perform more complicated sensing computation. However, the collaboration among heterogeneous sensors, such as the collaborative sensing mechanism, is not well studied in current state-of-art research. In this paper, we design and implement EasiSee, a real-time vehicle classification and counting system based on wireless sensor networks. Our contributions are as follows: (1) We propose a collaborative sensing mechanism, namely CSM, which coordinates the power-hungry camera sensor and the powerefficient magnetic sensors, reducing the overall system energy consumption and maximizing system lifetime. (2) We propose a robust vehicle image processing algorithm, LIPA. LIPA reduces environment noise and interference with a low computation complexity. In the verification section, the vehicle detection accuracy turned out to be 95.31%, which pave the way for CSM; The time of image processing is around 200ms, which indicates that our LIPA algorithm is of computational economical; With the overall energy consumption reduced, EasiSee achieves a classification accuracy of 93%. Based on these experiments and analysis, we conclude that EasiSee is an practical and low-cost affordable solution for traffic information acquisition.

## SMART DRIVING OF A VEHICLE USING MODEL PREDICTIVE CONTROL FOR IMPROVING TRAFFIC FLOW

KAMAL, MD. ABDUS SAMAD; IMURA, JUN-ICHI; HAYAKAWA, TOMOHISA; OHATA, AKIRA; AIHARA, KAZUYUKI

Traffic management on road networks is an emerging research field in the control engineering due to the strong demand to alleviate traffic congestion in urban areas. The interaction among vehicles frequently causes congestion as well as bottlenecks of road capacity. In dense traffic, waves of traffic density propagate backward as drivers try to keep safe distances with frequent acceleration and deceleration. This paper presents a vehicle driving system in a model predictive control framework that effectively improves a traffic flow. The vehicle driving system regulates a safe inter vehicle distance under the bounded driving torque condition by predicting the preceding traffic. It also focuses on alleviating the effect of braking on the vehicles following behind that helps jamming waves attenuate in the traffic. The proposed vehicle driving system has been evaluated through numerical simulation in dense traffic.

## SPATIAL AND TEMPORAL PATTERNS IN LARGE-SCALE TRAFFIC SPEED PREDICTION

ASIF, MUHAMMAD TAYYAB; DAUWELS, JUSTIN; GOH, CHONG YANG; ORAN, ALI; FATHI, ESMAIL; XU, MUYE; DHANYA, MENOTH MOHAN; MITROVIC, NIKOLA; JAILLET, PATRICK

The ability to accurately predict traffic speed in a large and heterogeneous road network has many useful applications, such as route guidance and congestion avoidance. In principle, data driven methods such as Support Vector Regression (SVR) can predict traffic with high accuracy, because traffic tends to exhibit regular patterns over time.

However, in practice, the prediction performance can vary significantly across the network and during different time periods. Insight into those spatial and temporal trends can improve the performance of Intelligent Transportation Systems (ITS). Traditional prediction error measures such as Mean Absolute Percentage Error (MAPE) provide information about individual links in the network, but do not capture global trends. We propose unsupervised learning methods, such as k-means clustering, Principal Component Analysis (PCA), and Self Organizing Maps (SOM) to mine spatial and temporal performance trends at both network level and for individual links. We perform prediction for a large, interconnected road network, for multiple prediction horizons, with SVR based algorithm. We show the effectiveness of the proposed performance analysis methods by applying them to the prediction data of SVR.

## GNSS ACCURACY IMPROVEMENT USING RAPID SHADOW TRANSITIONS

BEN-MOSHE, BOAZ; DVIR, AMIT; YOZEVITCH, ROI

Receiver modules in Global Navigation Satellite Systems (GNSS) are capable of providing positioning and velocity estimations that are sufficiently accurate for the purpose of road navigation. Yet, even in optimal open-sky conditions, GNSS-based positioning carries an average error of 2-4 meters. This imposes an effective limitation on GNSS-based vehicle lane detection, a desired functionality for various navigation and safety applications. In this paper, we present a novel framework for lane-level accuracy using GNSS devices and 3D shadow matching. The suggested framework is based on detection and analysis of rapid changes in navigation satellites' signal-strength, caused by momentary blockages due to utility and light poles. A method for detecting such momentary changes between line-of-sight (LOS) and non-line-of-sight (NLOS) is presented, followed by a geometric algorithm that improves location-accuracy of commercial GNSS devices. We have tested the framework's applicability using both simulations and field experiments. We provide the results of these tests, and discuss receiver-side sampling-rate requirements for high-performance lane-level positioning.

## SIZING FINITE POPULATION VEHICLE POOLS

CARPENTER, TOMMY; KESHAV, S; WONG, JOHNNY

We refer to a vehicle pool as a number of vehicles at a single location used for the same purpose. We focus on the problem of sizing vehicle pools for a finite set of subscribers who can use the pool. Our goal is to minimize the number of vehicles in the pool while still meeting nearly all subscriber requests. Formally, we propose three analytical techniques to size a vehicle pool for a finite population of subscribers according to the pools' busy period demand to guarantee all requests are served with probability  $1-\epsilon$ , a quality-of-service (QOS) guarantee. Moreover, we propose an additional heuristic sizing method which requires no prior data about pool demand. Although this method does not provide probabilistic bounds on QOS, we show in practice it still achieves a high QOS. We evaluate our sizing methodologies using seven years of data from a local car share using three performance metrics: availability (percentage of requests served), utilization (the percentage of time vehicles in the pool are used), and the member-to-vehicle ratio (the size of the pool relative to the size of its user population). We show that our methods perform well with respect to these metrics.

## STOCHASTIC PARK-AND-CHARGE BALANCING FOR FULLY ELECTRIC AND PLUG-IN HYBRID VEHICLES

HÄUSLER, FLORIAN; CRISOSTOMI, EMANUELE; SCHLOTE, ARIEH; RADUSCH, ILJA; SHORTEN, ROBERT

Motivated by the need to provide services to alleviate range anxiety of electric vehicles, we consider the problem of balancing charging demand across a network of charging stations. Our objective in doing this is to reduce the potential for excessively long queues to build up at some charging stations, while other charging stations are under-utilized. A stochastic balancing algorithm is presented to achieve these goals. A further feature of this algorithm is that it is fully decentralized and facilitates plug-and-play type behavior. Using our system, charging stations can join and leave the network without any changes to, or communication with, a centralized infrastructure. Analysis and simulations are presented to illustrate the efficacy of our algorithm.

## DEVELOPMENT AND EVALUATION OF AN INTELLIGENT ENERGY MANAGEMENT STRATEGY FOR PLUG-IN HYBRID ELECTRIC VEHICLES

WU, GUOYUAN; BORIBOONSOMSIN (MAGAZINE AE), KANOK; BARTH, MATTHEW

There has been significant interest in plug-in hybrid electric vehicles (PHEVs) as a means to decrease dependence on imported oil and to reduce greenhouse gases as well as other pollutant emissions. One of the critical considerations in PHEV development is the design of its energy management strategy, which determines how energy in a hybrid powertrain should be produced and utilized as a function of various vehicle parameters. In this study, we propose an intelligent energy management strategy for PHEVs. At the trip level, the strategy takes into account a priori knowledge of vehicle location, roadway characteristics, and real-time traffic conditions on the travel route from intelligent transportation system technologies in generating a synthesized velocity trajectory for the trip. The synthesized velocity trajectory is then used to determine battery's charge-depleting control that is formulated as a mixed integer linear programming problem to minimize the total trip fuel consumption. The strategy can be extended to optimize vehicle fuel consumption at the tour level if a pre-planned travel itinerary for the tour and the information about available battery recharging opportunities at intermediate stops along the tour are available. The effectiveness of the proposed strategy, both for the trip-based and tour-based controls, was evaluated against the existing binary mode energy management strategy using real-world trip/tour examples in Southern California. The evaluation results show that the fuel savings of the proposed strategy over the binary mode strategy are around 10-15%.

## A MACROSCOPIC SIGNAL OPTIMIZATION MODEL FOR ARTERIALS UNDER HEAVY MIXED TRAFFIC FLOWS

CHEN, YEN-YU; CHANG, GANG-LEN

This paper presents a generalized signal optimization model for arterials experiencing multiclass of traffic flows. Instead of using conversion factors for non-passenger cars, the proposed model applies a macroscopic simulation concept to capture the complex interactions between different types of vehicles from link entry, propagation, to intersection queue formation and discharging. Since both vehicle size and link length are considered in modeling traffic evolution, the resulting signal timings can best prevent the queue spillback due to insufficient link or bay length

under congested traffic conditions and the presence of a high percentage of transit or other types of large vehicles. The efficiency of the proposed model has been compared with the benchmark program, TRANSYT-7F, under both passenger flows only and multiclass traffic scenarios from modest to saturated traffic conditions. Using the MOEs of average delay per intersection approach and over the entire network and the total arterial throughput during the control period, our extensive numerical results have demonstrated our model's superior performance during congested and/or multiclass traffic conditions. The success of the proposed method may offer a new signal design for many arterials in congested downtowns or megacities in developing countries where transit vehicles constitute a major portion of traffic flows.

## THE PATH INFERENCE FILTER: MODEL-BASED LOW-LATENCY MAP MATCHING OF PROBE VEHICLE DATA

HUNTER, TIMOTHY; ABBEEL, PIETER; BAYEN, ALEX

We consider the problem of reconstructing vehicle trajectories from sparse sequences of GPS points, for which the sampling interval is between one second and two minutes. We introduce a new class of algorithms, called altogether path inference filter (PIF), that maps GPS data in real time, for a variety of trade-offs and scenarios, and with a high throughput. Numerous prior approaches in map-matching can be shown to be special cases of the path inference filter presented in this article. We present an efficient procedure for automatically training the filter on new data, with or without ground truth observations. The framework is evaluated on a large San Francisco taxi dataset and is shown to improve upon the current state of the art. This filter also provides insights about driving patterns of drivers. The path inference filter has been deployed at an industrial scale inside the Mobile Millennium traffic information system, and is used to map fleets of data in San Francisco, Sacramento, Stockholm and Porto.

## A MACROSCOPIC FORECASTING FRAMEWORK FOR ESTIMATING SOCIO-ECONOMIC AND ENVIRONMENTAL PERFORMANCE OF INTELLIGENT TRANSPORT HIGHWAYS

KOLOSZ, BEN; GRANT-MULLER, SUSAN; DJEMAME, KARIM

The anticipated introduction of new forms of Intelligent Transport Systems represents a significant opportunity for increased cooperative mobility and socio-technical changes within the transport system. Although such technologies are currently technical feasible, various socio-economic and environmental barriers impede their arrival. This paper uses a recently developed ITS performance assessment framework, known as EnvFUSION (Environmental Fusion) to perform dynamic forecasting of the performance for three key ITS technologies: Active Traffic Management, Intelligent Speed Adaptation and an Automated Highway System using a mathematical theory of evidence. A c-LCA (consequential lifecycle assessment) is undertaken which forms part of a data fusion process using data from various sources. The models forecast improvements for the three ITS technologies in-line with social acceptability, economic profitability and major carbon reduction scenarios up to 2050 on one of the UK's most congested highways. Analytical Hierarchy Process and Dempster-Shafer theory are used to weight criteria which form part of an Intelligent Transport Sustainability Index. Overall performance is then synthesized. Results indicate that there will be a substantial increase in socio-economic and emissions benefits, provided that the policies are in place and targets are reached which would otherwise delay their realization.

## AN AXIOMATIC DESIGN APPROACH TO PASSENGER ITINERARY ENUMERATION IN RECONFIGURABLE TRANSPORTATION SYSTEMS

VISWANATH, ASHA; SAMANO BACA, EDGAR; FARID, AMRO

Transportation systems represent a critical infrastructure upon which nations' economies and national security depend. As infrastructure systems, they must be planned and operated to accommodate the uncertain and continually evolving needs of their passengers and freight. New roads are planned or existing ones are closed for maintenance or due to operational breakdowns. Reconfigurable transportation systems are those which to these changes quickly and efficiently. They are not over-designed with capabilities that may be left unused, instead capabilities are added only when needed; thus supporting the need for *resilient* infrastructure. An axiomatic design for large flexible systems approach is chosen as a methodology for its deep roots in engineering design. It addresses systems where many functional requirements not only evolve over time, but also can be fulfilled by one or more design parameters, is used here to enumerate passenger itineraries. This paper builds upon a recent work in which axiomatic design was used to develop a theory of degrees of freedom in transportation systems for their reconfigurable design and operation. The methodological developments are then demonstrated on a small subsection of the Mexico City transportation system to demonstrate its wide ranging utility in reconfigurability decision-making at the planning and operations time scales. Also further comparisons of axiomatic design to traditional graph theory are made indicating the mathematical basis of the former in the latter.

## DIRECT AND STEERING TILT ROBUST CONTROL OF NARROW VEHICLES

MOURAD, LAMA; CLAVEAU, FABIEN; CHEVREL, PHILIPPE

Narrow Tilting Vehicles (NTVs) are the convergence of a car and a motorcycle. They are expected to be the new generation of city cars considering their practical dimensions and lower energy consumption. However, due to their height to breadth ratio, in order to maintain lateral stability, NTVs should tilt when cornering. Unlike the motorcycle, where the driver tilts the vehicle himself, the tilting of an NTV should be automatic. Two tilting systems are available; Direct and Steering Tilt Control, the combined action of these two systems being certainly the key to improve considerably NTV dynamic performances. In this paper, multivariable control tools (H2 methodology) are used to design, in a systematic way, lateral assistance controllers driving DTC, STC or both DTC/STC systems. A three degrees of freedom model of the vehicle is used, as well as a model of the steering signal, leading to a two degrees of freedom low order controller with an efficient feedforward anticipative part. Taking advantage of all the available measurements on NTVs, the lateral acceleration is directly regulated. Finally, a gain-scheduling solution is provided to make the DTC, STC, and DTC/STC controllers robust to longitudinal speed variations.

## GENERATION OF A PRECISE ROADWAY MAP FOR AUTONOMOUS CARS

JO, KICHUN; SUNWOO, MYOUNGHO

This paper proposes a map generation algorithm for a precise roadway map designed for autonomous cars. The roadway map generation algorithm is composed of three steps: data acquisition, data processing, and road modeling. In the data acquisition step, raw trajectory and motion data for map generation are acquired through exploration

using a probe vehicle equipped with GPS and on-board sensors. The data processing step then processes the acquired trajectory and motion data into roadway geometry data. GPS trajectory data are unsuitable for direct roadway map use by autonomous cars due signal interruptions and multipath; therefore, motion information from the on-board sensors are applied to refine the GPS trajectory data. A fixed-interval optimal smoothing theory is used for a refinement algorithm that can improve the accuracy, continuity, and reliability of road geometry data. Refined road geometry data are represented into the B-spline road model. A gradual correction algorithm is proposed to accurately represent road geometry with a reduced amount of control parameters. The developed map generation algorithm is verified and evaluated through experimental studies under various road geometry conditions. The results show that the generated roadway map is sufficiently accurate and reliable to utilize for autonomous driving.

## FAULT-TOLERANT ADAPTIVE CONTROL OF HIGH SPEED TRAINS UNDER TRACTION/BRAKING FAILURES – A VIRTUAL PARAMETER BASED APPROACH

SONG, YONGDUAN; SONG, QI; CAI, WENCHUAN

Advanced control is a key technology for enhancing safe and reliable operation of high speed trains. This paper presents an automated train control scheme for high speed train with combined longitudinal aerodynamics and tracking/braking dynamics, with special emphasis on reliable position and velocity tracking in the face of traction/braking failures. The controller is synthesized using a so-called virtual parameter based backstepping adaptive control method, which exhibits several salient features: 1) the inherent coupling effects are taken into account as a result of combining both longitudinal aerodynamics and traction/braking dynamics; 2) fully parameter independent rather than partially parameter independent control algorithms are derived; and 3) closed-loop tracking stability of the overall system is ensured under unnoticeable time-varying traction/braking failures. The effectiveness of the developed control scheme is authenticated via a formative mathematical analysis based on Lyapunov stability theory and also validated via numerical simulations.

## CONTROLLER SYNTHESIS FOR STRING STABILITY OF VEHICLE PLATOONS

PLOEG, JEROEN; SHUKLA, DIPAN; VAN DE WOUW, NATHAN; NIJMEIJER, HENK

Cooperative Adaptive Cruise Control (CACC) allows for short-distance automatic vehicle following using intervehicle wireless communication in addition to onboard sensors, thereby potentially improving road throughput. In order to fulfill performance, safety, and comfort requirements, a CACC-equipped vehicle platoon should be string stable, attenuating the effect of disturbances along the vehicle string. Therefore, a controller design method is developed that allows for explicit inclusion of the string stability requirement in the controller synthesis specifications. To this end, the notion of string stability is introduced first and conditions for  $L_2$  string stability of linear systems are presented that motivate the development of an  $H_\infty$  controller synthesis approach for string stability. The potential of this approach is illustrated by its application to the design of controllers for CACC for a one- and a two-vehicle look-ahead communication topology. As a result,  $L_2$  string stable platooning strategies are obtained in both cases, also revealing that the two-vehicle look-ahead topology is particularly effective at a larger communication delay. Finally, the results are experimentally validated using a platoon of three passenger vehicles, illustrating the practical feasibility of this approach.

## AN EFFICIENT HARDWARE IMPLEMENTATION OF HOG FEATURE EXTRACTION FOR HUMAN DETECTION

CHEN, PEI-YIN; HUANG, CHIEN-CHUAN; LIEN, CHIH-YUAN; TSAI, YU-HSIEN

In intelligent transportation systems, human detection is an important issue and has been widely used in many applications. HOG is proven to be able to significantly outperform existing feature sets for human detection. In this paper, we present a low-cost high-speed hardware implementation for HOG feature extraction. The simulation shows that the proposed circuit can achieve 167 MHz with 153K gate counts by using TSMC 0.13 $\mu$ m technology. Compared with the previous hardware architectures for HOG feature extraction, our circuit requires less hardware cost and achieves faster working speed.

## COMBINING PRIORS, APPEARANCE AND CONTEXT FOR ROAD DETECTION

ALVAREZ, JOSÉ M.; LÓPEZ, ANTONIO M.; GEVERS, THEO; LUMBRERAS, FELIPE

Detecting road areas ahead of a moving vehicle is an important research topic in different areas of computer vision such as autonomous driving or car collision warning. Current vision-based road detection methods are usually based solely on low-level features. Further, they generally assume structured roads, road homogeneity, and uniform lighting conditions constraining their applicability in real-world scenarios. In this paper, road priors and contextual information are introduced for road detection. First, we propose an algorithm to estimate road priors on-line using geographical information providing relevant initial information about the road location. Then, contextual cues including horizon lines, vanishing points, lane markings, 3D scene layout and road geometry are used in addition to low-level cues derived from the appearance of roads. Finally, a generative model is used to combine these cues and priors leading to a road detection method that is, to a large degree, robust to varying imaging conditions, road types and scenarios.

## 2-HB LEVEL CROSSINGS VS. 4-HB LEVEL CROSSINGS: A COMPARATIVE RISK ANALYSIS STUDY

GHAZEL, MOHAMED; EL-KOURSI, EL-MILOUDI

Safety is a key issue in railway operation. In this context, level crossings are one of the most critical points in railway networks. In some countries, accidents at LC account for up to 50% of railway accidents. In this paper, we conduct a risk assessment comparative study involving two main types of Automatic Protection Systems (APS), the first using a pair of half-barriers and the second with four half-barriers. So far, the choice of such LC protection systems has been exclusively done on the basis of qualitative expertise. The study we carry out here is based on some parameterizable behavioral models we have developed, which describe the global dynamics within the LC area. In contrast to existing studies on LC safety, our models take into account, not only railway and road traffic, but also the risk due to human factors while focusing on two major risky situations. The simulation results clearly show the potential risk with each of the investigated APSs, according to various features of the dynamics within the level crossing area. To the best of our knowledge, this is the first work dealing with a quantitative comparison between different types of level crossings. The developed models can be easily accommodated in order to describe existing infrastructures.



## WEB-BASED TRAFFIC SENTIMENT ANALYSIS: METHODS AND APPLICATIONS

CAO, JIANPING; ZENG, KE; WANG, HUI; CHENG, JIAJUN; QIAO, FENGCAI; WEN, DING; GAO, YANQING

Abstract—With the booming of social media in recent years, sentiment analysis has developed rapidly. However, there are few applications of sentiment analysis in the field of transportation to meet the stringent requirements of safety, efficiency, and information exchange. We proposed the traffic sentiment analysis as new tool to tackle this problem, it does provide a new prospective for modern intelligent transportation systems. Methods and models in traffic sentiment analysis are proposed in this study. And the advantages and disadvantages of rule- and learning-based approaches are analyzed based on Web data. For practical purposes, we applied the rule-based approach to deal with this problem, presented an architectural design, constructed related bases, demonstrated the process, and provided details on online data collection. We presented two case studies: one regarding the “yellow light rule” and the other concerning the “fuel price” in China.

## MODELLING AND ANALYSIS OF AN INFRASTRUCTURE SERVICE REQUEST QUEUE IN MULTI-CHANNEL V2I COMMUNICATIONS

KHABBAZ, MAURICE; HASNA, MAZEN; ASSI, CHADI; GHRAYEB, ALI

This paper presents a concise yet comprehensive description of a multi-channel Vehicle-to-Infrastructure (V2I) communication system. Existing mathematical models for such a system overlook some of its essential behavioural characteristics such as the reneging, force-termination and ultimately blocking of service requests. Thus, the reported performance results obtained from these models seem to be unrealistically overoptimistic. Accordingly, in this paper, a multi-server queuing model is proposed for the purpose of accurately capturing the dynamics of the above-mentioned communication system and evaluating its performance. The proposed model is renowned for its complexity and the non- existence of closed-form analytical expressions that characterize its fundamental performance metrics. Hence, approximations were exploited as a mean to enhance this model’s mathematical tractability. Simulations are conducted in the context of a realistic scenario with the objective of validating the proposed approximate model, verifying its accuracy and characterizing the system’s performance in terms of several new metrics. The simulations’ results indicate a cataclysmic service request blocking probability in the range of 65% to 85%.

## COMPARISON OF THREE ELECTROCHEMICAL ENERGY BUFFERS APPLIED TO A HYBRID BUS POWERTRAIN WITH SIMULTANEOUS OPTIMAL SIZING AND ENERGY MANAGEMENT

HU, XIAOSONG; MURGOVSKI, NIKOLCE; JOHANNESSEN, LARS; EGARDT, BO

This paper comparatively examines three different electrochemical energy storage systems (ESSs), i.e., Li-ion battery, supercapacitor, and dual buffer, for a hybrid bus powertrain operated in Gothenburg, Sweden. Existing studies focus on comparing these ESSs in terms of either general attributes (e.g., energy density and power density) or their implications to the fuel economy of hybrid vehicle with a heuristic/non-optimal ESS size and power management strategy. This paper adds four original contributions to the related literature. First, the three ESSs are compared in a framework of simultaneous optimal ESS sizing and energy management, where the ESSs can serve the powertrain in a

most cost-effective manner. Second, convex optimization is used to implement the framework, which allows the hybrid powertrain designers/integrators to rapidly and optimally perform integrated ESS selection, sizing, and power management. Third, both hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV) scenarios for the powertrain are considered, in order to systematically examine how different the ESS requirements are for HEV and PHEV applications. Finally, a sensitivity analysis is carried out to evaluate how price variations of the on-board energy carriers affect the results and conclusions.

## USING A HEAD-UP DISPLAY-BASED STEADY STATE VISUAL EVOKED POTENTIALS BRAIN-COMPUTER INTERFACE TO CONTROL A SIMULATED VEHICLE

BI, LUZHENG; FAN, XIN-AN; JIE, KE; TENG, TENG; DING, HONGSHENG; LIU, YILI

In this paper, we propose a new Steady State Visual Evoked Potentials (SSVEP) brain-computer interface (BCI) with visual stimuli presented on a windshield via a head-up display (HUD) and we apply this BCI in conjunction with alpha rhythm for controlling a simulated vehicle with a 14 degree of freedom (DOF) vehicle dynamics model. A linear discriminant analysis (LDA) classifier is applied to detect alpha rhythm, which is used to control the start and stopping of the vehicle. The classification models of the SSVEP BCI with three commands (i.e., turning left, turning right, and going forward) are built by using Support Vector Machine with frequency domain features. A real-time brain-controlled simulated vehicle is developed and tested by using four participants to perform a driving task online, including vehicle starting and stopping, lane keeping, avoiding obstacle, and curve negotiation. The experimental results show the feasibility of using the human “mind” alone to control a vehicle, at least for some users.

## TIRE RADII ESTIMATION USING A MARGINALIZED PARTICLE FILTER

LUNDQUIST, CHRISTIAN; KARLSSON, RICKARD; ÖZKAN, EMRE; GUSTAFSSON, FREDRIK

In this work measurements of individual wheel speeds and absolute position from a global positioning system (GPS) are used for high-precision estimation of vehicle tire radii. The radii deviation from its nominal value is modeled as a Gaussian random variable and included as noise components in a simple vehicle motion model. The novelty lies in a Bayesian approach to estimate online both the state vector and the parameters representing the process noise statistics using a marginalized particle filter. Field tests show that the absolute radius can be estimated with sub-millimeter accuracy. The approach is tested in accordance with the ECE R-64 regulation on a large data set (22 tests, using two vehicles and 12 different tire sets), where tire deflations are detected successfully, with high robustness, i.e., no false alarms. The proposed marginalized particle filter approach outperforms common Kalman filter based methods used for joint state and parameter estimation when compared with respect to accuracy and robustness.

# Abstracts of forthcoming IEEE ITS Magazine papers

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## A FRAMEWORK FOR SUPPORTING NETWORK CONTINUITY IN VEHICULAR IPV6 COMMUNICATIONS

SANTA, JOSÉ; PEREÑIGUEZ-GARCÍA, FERNANDO; BERNAL, FERNANDO; FERNÁNDEZ, PEDRO; MARÍN-LÓPEZ, RAFAEL; GOMEZ-SKARMETA, ANTONIO

The appearance of recent standards about cooperative ITS architectures towards a reference communication stack has been an inflection point in the research about vehicular networks. The ISO Communication Access for Land Mobiles (CALM) and the ETSI European ITS communication architecture have paved the way towards real and interoperable vehicular cooperative systems. Within these convergent proposals, IPv6 communications are recognized as a key component to enable traffic efficiency and infotainment applications. The proper operation of these applications and the achievement of value-added ITS services require an uninterrupted network connectivity. This paper addresses this problem by proposing a novel communication stack to support the provision of continuous and secure IPv6 vehicular communications. The solution follows the ISO/ETSI guidelines for the development of cooperative ITS systems and is based on standardized technologies such as Network Mobility (NEMO) protocol to provide an integral management of IPv6 mobility. The solution integrates IEEE 802.21 media independent handover services for optimizing the handover process. While the support to the handover optimization offered by the proposed ITS communication stack is demonstrated through a mobility use case, a real testbed supporting most of the communications features is developed to validate and assess the real performance of the stack design.

## ESTIMATING REQUIRED PROBE VEHICLE RE-IDENTIFICATION REQUIREMENTS FOR CHARACTERIZING LINK TRAVEL TIMES

ERNST, JOSEPH; KROGMEIER, JAMES; BULLOCK, DARCY

In the 1970s a framework was developed by Oppenlander to determine the sample size required for travel time estimation studies. This framework is still recommended today. This paper develops a new framework to improve upon the ideas set forth by Oppenlander. This new framework is based upon the Kullback-Leibler divergence. It allows for travel time studies to be evaluated in a more comprehensive way. Travel time estimation methods can now be evaluated on their ability to estimate travel time distributions instead of only the mean travel time. Also, this framework can be used on any travel time distribution whereas the Oppenlander framework was only properly suited for Gaussian distributions. The Kullback-Leibler divergence also allows for comparing both ID matching (i.e., small sample sizes with no erroneous travel times) and signature matching (i.e., large sample sizes mixed with some erroneous travel times) travel time estimation algorithms to be evaluated, while the Oppenlander framework was best suited for the ID matching algorithms. In this paper the Kullback-Leibler comparison framework for travel time studies is developed. The framework is then used to provide a comparison of an example ID matching and an example signature matching algorithm to demonstrate how both can be evaluated in a single framework. Finally, conclusions are made about the usefulness of the Kullback-Leibler comparison framework.

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