VEHITS 2020

6th International Conference on Vehicle Technology and Intelligent Transport Systems

Final Program and Book of Abstracts

2 - 4 May, 2020

http://www.vehits.org

SPONSORED BY

INSTICC

PAPERS AVAILABLE AT

SCITEPRESS DIGITAL LIBRARY

VEHITS 2020
Final Program and Book of Abstracts

6th International Conference on Vehicle Technology and Intelligent Transport Systems

Online Streaming
May 2 - 4, 2020

Sponsored by
INSTICC - Institute for Systems and Technologies of Information, Control and Communication

In Cooperation with
CVTA - Connected Vehicle Trade Association
ITS Portugal
APVE - Portuguese Electric Vehicle Association

Printed in Portugal
http://www.vehits.org
vehits.secretariat@insticc.org

Table of Contents

Foreword

This book contains the abstracts and final program of the 6th International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS 2020) which was sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC) and held in cooperation with the Connected Vehicle Trade Association (CVTA), the Association for the Development of Mobility and Sustainable Transportation (ITS PORTUGAL) and the Portuguese Association of Electric Vehicle (APVE). This year VEHITS was, exceptionally, held as a web-based event, due to the Covid-19 pandemic, from 2 - 4 May.

VEHITS focuses on innovative applications, tools and platforms in all technology areas such as signal processing, wireless communications, informatics and electronics, related to different kinds of vehicles, including cars, off-road vehicles, trains, ships, underwater vehicles, or flying machines, and the intelligent transportation systems that connect and manage large numbers of vehicles, not only in the context of smart cities, but in many other application domains.

This conference brought together researchers and practitioners interested in the advances and applications in the field of Vehicle Technology and Intelligent Transport Systems. It had five main topic areas, covering different aspects, including Connected Vehicles, Data Analtyics, Intelligent Transport Systems and Infrastructure, Intelligent Vehicle Technologies and Smart Mobility and Sustainable Transport Services.

We believe the diversity and scope of the papers in these proceedings reflect the richness of the technical problems in each field and show clearly how new and innovative solutions are being devised to solve them. The conference was also complemented with a Special Session on Intelligent Mobility, Logistics and Transport - iMLTrans 2020, chaired by Irina Makarova, Maria Drakaki and Ksenia Shubenkova.

VEHITS 2020 received 94 paper submissions, including the special session, from 30 countries in all continents, of which 30% were accepted as full papers. The high quality of the papers received imposed difficult choices during the review process. To evaluate each submission, a double blind paper review was performed by the Program Committee, whose members are highly qualified independent researchers in the VEHITS 2020 topic areas.

The high quality of VEHITS 2020 was also enhanced by the keynote lectures delivered by internationally known experts, namely Reinhold Behringer (Knorr Bremse GmbH, Germany) , Meng Lu (Dynniq, Netherlands) and Tolga Bektas (University of Liverpool Management School, United Kingdom).

The best academic and industrial contributions to the conference and the best student submissions were distinguished with awards based on the combined marks of paper reviewing, as assessed by the Program Committee, and the quality of the presentation, as evaluated by session chairs at the conference.

Building an interesting and successful program for the conference required the dedicated effort of many people. We would like to express our thanks, first of all, to all authors who submitted papers to VEHITS 2020. We would also like to express our gratitude to all members of the Program Committee and auxiliary reviewers, who helped us with their expertise and valuable time. Furthermore, we thank the invited speakers for their invaluable contribution and for taking the time to synthesize and prepare their talks.

Finally, we gratefully acknowledge the professional support of the INSTICC team for all organizational processes, especially given the need to introduce online streaming, forum management, direct messaging facilitation and other web-based activities in order to make it possible for VEHITS 2020 authors to present their work and share ideas with colleagues in spite of the logistic difficulties caused by the current pandemic situation.

We hope that all colleagues who participated in the conference and/or read its proceedings, find this a fruitful and inspiring conference. We look forward to the further development of the Vehicle Technology and Intelligent Transport Systems community and look forward to having additional research results presented at the next edition of VEHITS, details of which are available at http://www.vehits.org/.

Karsten Berns, University of Kaiserslautern, Germany
Markus Helfert, Maynooth University, Ireland
Oleg Gusikhin, Ford Motor Company, United States

Important Information

Event App
Download the Event App from the Play Store and App Store now, to have mobile access to the technical program and also to get notifications and reminders concerning your favorite sessions.

Create Your Own Schedule *
The option “My Program” gives you the possibility of creating a selection of the sessions that you plan to attend. This service also allows you to print-to-pdf all papers featured in your selection thus creating a pdf file per conference day.

Online Access to the Proceedings *
In the option “Proceedings and Final Program” you cannot only download the proceedings but also access the digital version of the book of abstracts with the final program.

Digital Access to the Receipt *
By clicking on the option “Delegate Home” and then “Registration Documents” it will enable you to access the final receipt which confirmes the registration payment.

Keynotes Videos
The keynote lectures will also be available on video on the website after the event, as long as the appropriate authorization from the keynote is received, so you will be able to see them again or watch them should you have missed one.

Survey
Every year we conduct a survey to access the participants’ satisfaction with the conference and gather the suggestions. You will receive an e-mail after the event with the detailed information. Your contribution will be carefully analysed and a serious effort to react appropriately will be made.

* Please login to PRIMORIS (www.insticc.org/Primoris), select the role “Delegate” and the correct event.

If you have any doubt, we will be happy to help you at the Welcome Desk.

General Information

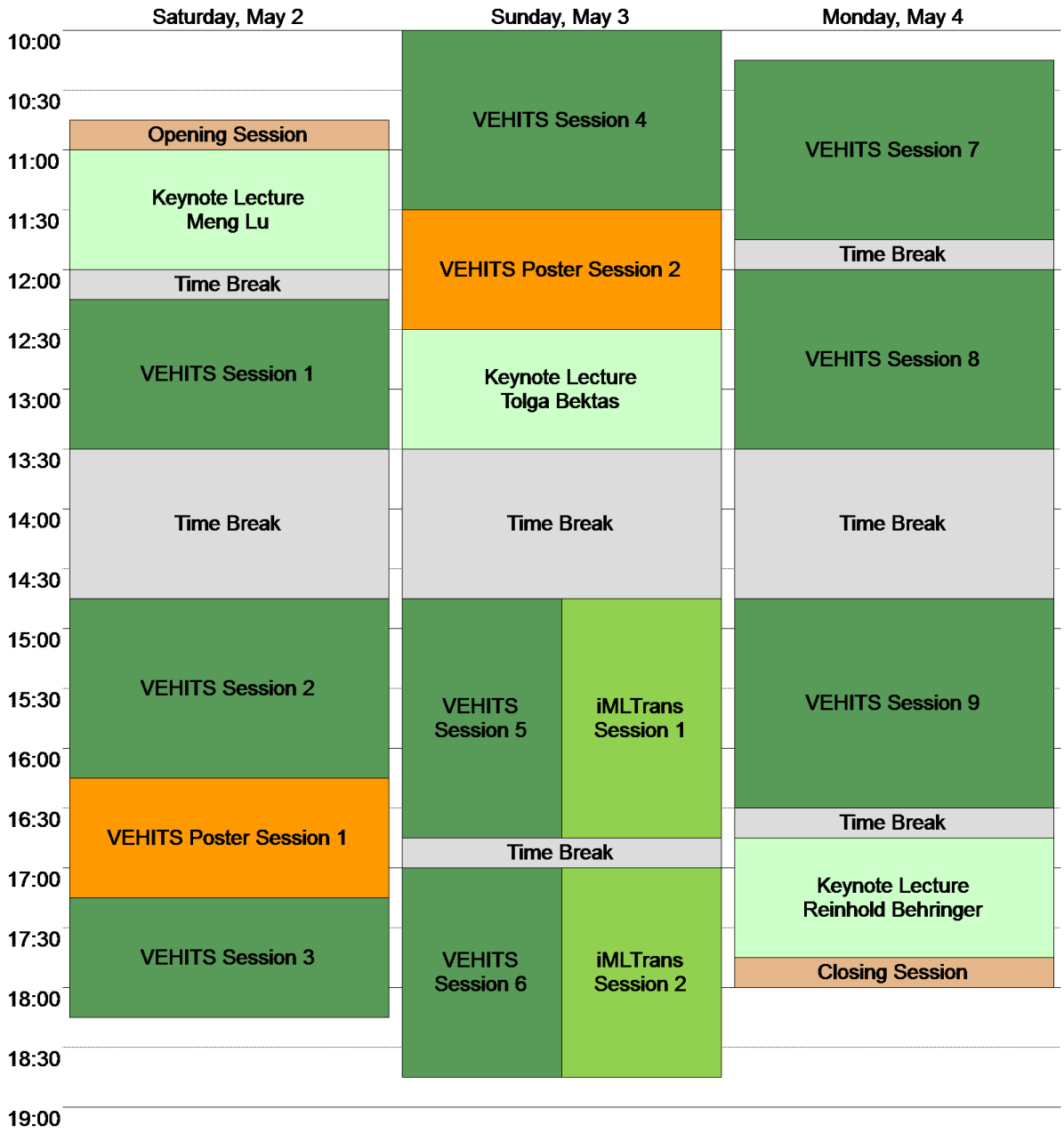
Welcome Desk
Saturday, May 2 – Open from 10:30 to 18:15
Sunday, May 3 – Open from 09:45 to 18:45
Monday, May 4 – Open from 10:00 to 18:00

Opening Session
Saturday, May 2, at 10:45 in the Plenary room.

Closing Session
Monday, May 4, at 17:45 in the Plenary room.

Secretariat Contacts
VEHITS Secretariat
Address: Avenida de S. Francisco Xavier, Lote 7 Cv. C
2900-616 Setúbal, Portugal
Tel.: +351 265 520 185
Fax: +351 265 520 186
e-mail: vehits.secretariat@insticc.org
website: http://www.vehits.org

Program Layout



Final Program and Book of Abstracts

Contents

Saturday Sessions: May 2

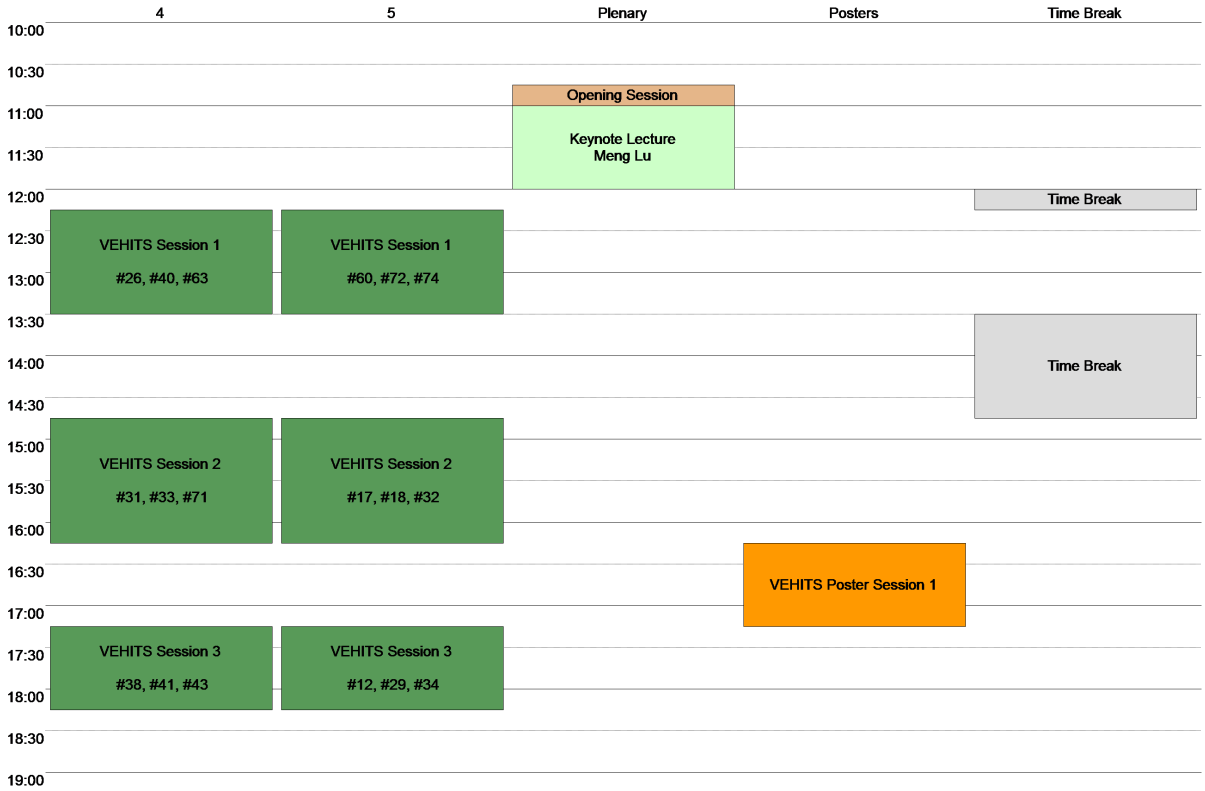
Sunday Sessions: May 3

Contents

Monday Sessions: May 4

Saturday Sessions: May 2

Saturday Sessions: May 2 Program Layout



Opening Session	VEHITS
10:45 - 11:00	Room Plenary

Keynote Lecture	VEHITS
11:00 - 12:00	Room Plenary

Cooperative Intelligent Transport Systems: Towards High-Level Automated Driving

Meng Lu
Dynniq, The Netherlands

Abstract: Around fifteen years ago, the development of co-operative systems started. Short-range communication would provide connectivity between neighbouring vehicles to exchange information, both of their own position and velocity, and of information observed by vehicle sensors, e.g. concerning obstacles on the road or road surface conditions. The idea was that this would enable a whole range of new safety and driver comfort applications. Also other road users, especially vulnerable road users such as pedestrians and cyclists, could participate in such connectivity, now that smartphones had become widespread. Deployment of cooperative systems has been less rapid than of autonomous systems, partly due to the higher level of complexity of the technology. Also, these systems are less known by the general public. But certainly they are a prelude (and an indispensable component) of an even more advanced technology, which has come to rapid development in recent years, and is receiving widespread attention, also from the general public: automated driving. In view of its complexity, several levels of vehicle automation are distinguished, from no automation at all to high-level and full automation. This speech presents recent results of the ongoing efforts for development and deployment of cooperative systems for road transport. These systems use communication between vehicles, as well as between vehicles and infrastructure, other road users and network, for exchange of information, enabling various applications for safety, efficiency and comfort. Cooperative Intelligent Transport Systems (C-ITS), also referred to as connected vehicles, are a prelude to, and pave the way towards road transport automation. Vehicle connectivity and information exchange will be an important asset for future highly-automated driving The speech provides an insight in the state of the art of C-ITS, especially addresses the important role of ICT infrastructure, and presents the main achievements in recent European projects.

Time Break	VEHITS
12:00 - 12:15	Room Time Break

Session 1A	VEHITS
12:15 - 13:30	Room 4
Traffic Theory, Modeling, and Simulation	

Paper #26

Cooperative Maneuvers of Highly Automated Vehicles at Urban Intersections: A Game-theoretic Approach

Björn Koopmann, Stefan Puch, Günter Ehmen and Martin Fränzle
OFFIS e.V., Escherweg 2, 26121 Oldenburg, Germany

Keywords: Highly Automated Driving, Cooperative Driving, Intelligent Transportation Systems, Traffic Management, Intersection Management, Intelligent Infrastructure, Collaborative Sensing, Trajectory Planning, Traffic Efficiency, Road Safety, Vehicle-to-Everything Communication, Game Theory, Traffic Simulation.

Abstract: In this paper, we propose an approach how connected and highly automated vehicles can perform cooperative maneuvers such as lane changes and left-turns at urban intersections where they have to deal with human-operated vehicles and vulnerable road users such as cyclists and pedestrians in so-called mixed traffic. In order to support cooperative maneuvers the urban intersection is equipped with an intelligent controller which has access to different sensors along the intersection to detect and predict the behavior of the traffic participants involved. Since the intersection controller cannot directly control all road users and – not least due to the legal situation – driving decisions must always be made by the vehicle controller itself, we focus on a decentralized control paradigm. In this context, connected and highly automated vehicles use some carefully selected game theory concepts to make the best possible and clear decisions about cooperative maneuvers. The aim is to improve traffic efficiency while maintaining road safety at the same time. Our first results obtained with a prototypical implementation of the approach in a traffic simulation are promising.

Paper #63

A Validation Study of the Fadhloun-Rakha Car-following Model

Karim Fadhloun[1], Hesham Rakha[1], Amara Loulizi[2] and Jinghui Wang[1]

[1] *Virginia Tech Transportation Institute, Virginia Tech, 3500 Transportation Research Plaza, Blacksburg VA, U.S.A.*

[2] *LR11ES16 Laboratoire de Matériaux, d'Optimisation et d'Environnement pour la Durabilité, École Nationale d'Ingénieur de Tunis, Tunis, Tunisia*

Keywords: Rakha-Pasumarthy-Adjerid Car-following Model, Car-following Behavior, Vehicle Dynamics.

Abstract: The research presented in this paper investigates and validates the performance of a new car-following model (the Fadhloun-Rakha (FR) model). The FR model incorporates the key components of the Rakha-Pasumarthy-Adjerid (RPA) model in that it uses the same steady-state formulation, respects vehicle dynamics, and uses very similar collision-avoidance strategies to ensure safe following distances between vehicles. The main contributions of the FR model over the RPA model are the following: (1) it explicitly models the driver throttle and brake pedal input; (2) it captures driver variability; (3) it allows for shorter than steady-state following distances when following faster leading vehicles; (4) it offers a much smoother acceleration profiles; and

(5) it explicitly captures driver perception and control inaccuracies and errors. In this paper, a naturalistic driving dataset is used to validate the FR model. Furthermore, the model performance is compared to that of five widely used car-following models, namely: the Wiedemann model, the Frietzsche model, the Gipps model, the RPA model and the Intelligent Driver Model (IDM). A comparative analysis between the different model outputs is used to determine the performance of each model in terms of its ability to replicate the empirically observed driver/vehicle behavior. Through quantitative and qualitative evaluations, the proposed FR model is demonstrated to significantly decrease the modeling error when compared to the five aforementioned models and to generate trajectories that are highly consistent with empirically observed driver following behavior.

Paper #40

Towards a Better Management of Emergency Evacuation using Pareto Min Cost Max Flow Approach

Sreeja Kamishetty and Praveen Paruchuri
Machine Learning Lab, IIIT Hyderabad, Gachibowli, Hyderabad, India

Keywords: Emergency Evacuation, Intelligent Transportation, Pareto Solutions, Min-Cost Max Flow Algorithm, Traffic Theory, Modeling and Simulation, Cooperative Driving and Traffic Management.

Abstract: Events during an emergency unfold in an unpredictable fashion which makes management of traffic during emergencies pretty challenging. Furthermore, some vehicles would need to be evacuated faster than others e.g., emergency vehicles or large vehicles carrying a lot more people. The Prioritized Routing Assistant for Flow of Traffic (PRAFT) enables prioritized routing during emergencies. However, the PRAFT solution does not compute multiple plans that can help handle better dynamic nature of emergencies. PRAFT maps the prioritized routing problem to the Minimum-Cost Maximum-Flow (MCMF) problem, hence its solution can accommodate maximum flow while routing vehicles based on priority (maps higher priority vehicles to better quality routes (i.e., ones with minimum cost)). We build upon the PRAFT solution to make the following contributions: (a) Develop a Pareto Minimum-Cost Maximum-Flow (Pareto-MCMF) algorithm which can compute all the possible MCMF solutions. (b) Through a series of experiments performed using the well known traffic simulator SUMO, we could show that all the solutions generated by Pareto-MCMF indeed have properties similar to a MCMF solution thus providing multiple high quality options for traffic police to pick from depending on the situation.

Session 1B **VEHITS**
12:15 - 13:30 **Room 5**
Autonomous Vehicles and Automated Driving

Paper #60

Driving Fast but Safe: On Enforcing Operational Limits of a NMPC System

Adam Gotlib, Krzysztof Jóskowiak, Piotr Libera, Marcel Kaliński, Jakub Bednarek and Maciej Majek
Students' Robotics Association, Faculty of Power and Aeronautical Engineering, Warsaw University of Technology, ul. Nowowiejska 24, 00-665 Warsaw, Poland

Keywords: Autonomous Driving, Control Systems, Nonlinear Model Predictive Control.

Abstract: In this paper, we present a novel approach to Model Predictive Control that allows to explore the largest possible portion of the state–space when still using a low–computational–complexity vehicle model. By introducing additional constraint for acceleration magnitude we are able to stay within the limits where the model gives accurate predictions, while driving with high velocity. This effects a behavior similar to one of a professional racing driver, as the controller is able to balance speed and curvature of the vehicle at any point in time.

Paper #72

Trajectory Simulation Tool for Assessment of Active Vehicle Safety Systems

Chinmay Patil[1], Taehyun Shim[1], Jemyoung Ryu[2] and Seunghwan Chung[2]
[1] *Department of Mechanical Engineering, University of Michigan-Dearborn, Dearborn, U.S.A.*
[2] *Hyundai Kia Motors, South Korea*

Keywords: Simulation Tool, Path Planning, ADAS Test.

Abstract: Advanced Driver Assist Systems (ADAS) have been widely employed in the automotive industry to improve vehicle safety and to reduce the driver's workload. In addition, there are increasing efforts toward autonomous driving vehicles using enhanced ADAS technologies. For effective ADAS development, it is critical to test and validate these systems. This paper presents a vehicle simulation tool that can be used for various ADAS vehicle test scenarios in which it can generate vehicle trajectories and speed profiles that satisfy user defined test conditions. The proposed simulation tool is useful to design a test scenario in the simulation environment before the physical test. Thus, it can significantly reduce the time needed for the proper test scenario development.

Paper #74

Validity Analysis of Simulation-based Testing concerning Free-space Detection in Autonomous Driving

Fabio Reway, Maikol Drechsler, Diogo Wachtel and Werner Huber
CARISSMA, Technische Hochschule Ingolstadt, Germany

Keywords: Automated Driving, Testing, Validation, Simulation.

Abstract: Automated vehicles must perceive their environment and accordingly plan a safe trajectory to navigate. Camera sensors and image processing algorithms have been extensively used to detect free-space, which is an unoccupied area where a car can safely drive through. To reduce the effort and costs of real test drives, simulation has been increasingly used in the automotive industry to test such systems. In this work, an algorithm for free-space detection is evaluated across real and virtual domains under different environment conditions: daytime, night time and fog. For this purpose, an algorithm is implemented to ease the process of creating ground-truth data for this kind of test. Based on the evaluation of predictions against ground-truth, the test results from the real test scenario are compared with its corresponding virtual twin to analyze the validity of simulation-based testing of a free-space detection algorithm.

Time Break **VEHITS**
13:30 - 14:45 **Room Time Break**

Session 2A **VEHITS**
14:45 - 16:15 **Room 4**
Decision Support Systems

Paper #33

Self-aware Pedestrians Modeling for Testing Autonomous Vehicles in Simulation

Qazi Jan, Jan Kleen and Karsten Berns
Robotics Research Lab, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Keywords: Pedestrian Simulation, Pedestrian Path, Autonomous-vehicles, Testing, Virtual Pedestrians.

Abstract: With the rise of autonomous vehicles in the urban environment, the focus is also shifted towards autonomous vehicles in pedestrian zones. Pedestrian safety becomes the primary concern in such zones. Autonomous systems for these situations need thorough testing before its deployment in the real-world to ensure safety. Therefore, developing testbeds that resemble the real-world for autonomous vehicles testing in pedestrian zones are highly critical. The proposed work focuses on the modeling of pedestrian behaviors in a simulated environment for realizing autonomous vehicles in the pedestrian zones. The virtual pedestrians are modeled with the self-awareness to avoid static and dynamic obstacles when progressing towards its goal. The goal is also to have a minimum number of parameters to generate various test scenarios with realistic behaving pedestrians for the autonomous systems. The proposed system is evaluated using individual and group of virtual pedestrians. It can be seen from the experiments that simulated pedestrians show trajectories which resemble the trajectories of pedestrians in the real-world for that particular situation.

Paper #71

Tournament Selection Algorithm for the Multiple Travelling Salesman Problem

Giorgos Polychronis and Spyros Lalis
University of Thessaly, Volos, Greece

Keywords: Multiple Travelling Salesman Problem, Tournament Selection, Large Neighbourhood Search, Quality/Execution Time Trade-off.

Abstract: The multiple Travelling Salesman Problem (mTSP) is a generalization of the classic TSP problem, where the cities in question are visited using a team of salesmen, each one following a different, complementary route. Several algorithms have been proposed to address this problem, based on different heuristics. In this paper, we propose a new algorithm that employs the generic tournament selection heuristic principle, hybridized with a large neighbourhood search method to iteratively evolve new solutions. We describe the proposed algorithm in detail, and compare it with a state-of-the-art algorithm for a wide range of public benchmarks. Our results show that the proposed heuristic manages to produce solutions of the same or better quality at a significantly lower runtime overhead. These improvements hold for Euclidean as well as for general topologies.

Paper #31

Modelling Commuting Activities for the Simulation of Demand Responsive Transport in Rural Areas

Sergei Dytckov, Fabian Lorig, Paul Davidsson, Johan Holmgren and Jan Persson
Malmö University, Department of Computer Science and Media Technology, IoTaP Research Centre, K2 – The Swedish Knowledge Centre for Public Transport, Malmö, Sweden

Keywords: Demand Modelling, Gravity Model, Simulation, Case Study.

Abstract: For the provision of efficient and high-quality public transport services in rural areas with a low population density, the introduction of Demand Responsive Transport (DRT) services is reasonable. The optimal design of such services depends on various socio-demographical and environmental factors, which is why the use of simulation is feasible to support planning and decision-making processes. A key challenge for sound simulation results is the generation of realistic demand, i.e., requests for DRT journeys. In this paper, a method for modelling and simulating commuting activities is presented, which is based on statistical real-world data. It is applied to Sjöbo and Tomelilla, two rural municipalities in southern Sweden.

Session 2B **VEHITS**
14:45 - 16:15 **Room 5**
Autonomous Vehicles and Automated Driving

Paper #17

Classification of Driver Intentions at Roundabouts

Moritz Sackmann[1], Henrik Bey[1], Ulrich Hofmann[2] and Jörn Thielecke[1]
[1] *Institute of Information Technology, FAU Erlangen-Nürnberg, 91058 Erlangen, Germany*
[2] *Pre-Development of Automated Driving, AUDI AG, 85057 Ingolstadt, Germany*

Keywords: Automated Driving, Intention Classification, Trajectory Analysis, Pattern Recognition.

Abstract: Classification of other drivers' intentions is an important requirement for automated driving. We present two methods to estimate whether a driver leaves a roundabout. The first, like many other approaches to this problem, requires training data of the specific roundabout to extract typical behavior patterns. Afterwards, these patterns are used for classification of other drivers' intentions. The second approach generates typical behavior patterns from a precise map. Consequently, no training data is required and classification can be performed on arbitrary roundabouts as long as a map is available. Experimental evaluation on a real world dataset of 266 trajectories shows that the performance of the map-based approach is comparable to the data-driven approach. The classification result can be used in a later stage for behavior planning of automated vehicles or driver assistance systems.

Paper #18

Tutorial on Sampling-based POMDP-planning for Automated Driving

Henrik Bey[1], Maximilian Tratz[1], Moritz Sackmann[1], Alexander Lange[2] and Jörn Thielecke[1]

[1] *Institute of Information Technology, FAU Erlangen-Nürnberg, 91058 Erlangen, Germany*

[2] *Pre-development of Automated Driving, AUDI AG, 85045 Ingolstadt, Germany*

Keywords: Automated Driving, Decision Making under Uncertainty, POMDP.

Abstract: Behavior planning of automated vehicles entails many uncertainties. Partially Observable Markov Decision Processes (POMDP) are a mathematical framework suited for formulating the arising sequential decision problems. Solving POMDPs used to be intractable except for overly simplified examples, especially when execution time is of importance. Recent sampling-based solvers alleviated this problem by searching not for the exact but rather an approximated solution, and made POMDPs usable for many real-world applications. One of these algorithms is the Adaptive Belief Tree (ABT) algorithm which will be analyzed in this work. The scenario under consideration is an uncertain obstacle in the way of an automated vehicle. Following this example, the setup of POMDP and ABT is derived and the impact of important parameters is assessed in simulation. As such, this work provides a hands-on tutorial, giving insights and hints on how to overcome the pitfalls in using sampling-based POMDP solvers.

Paper #32

User-adaptive Eyelid Aperture Estimation for Blink Detection in Driver Monitoring Systems

Juan Ortega[1,2], Marcos Nieto[1], Luis Salgado[3] and Oihana Otaegui[1]

[1] *Vicomtech Foundation, Basque Research and Technology Alliance (BRTA), Donostia-San Sebastián, Spain*

[2] *Departamento de Señales, Sistemas y Radiocomunicaciones, ETS Ingenieros de Telecomunicación, Universidad Politécnica de Madrid (UPM), Madrid, Spain*

[3] *Grupo de Tratamiento de Imágenes, Information Processing and Telecommunications Center (IPTC) and ETS Ingenieros de Telecomunicación, Universidad Politécnica de Madrid (UPM), Madrid, Spain*

Keywords: Eyelid Aperture, Blink Detection, Driver Monitoring, Computer Vision, ADAS.

Abstract: This paper presents a new method for eyelid aperture estimation, suitable to be used in Driver Monitoring Systems (DMS) to measure blink patterns such as microsleeps and any other metric that assess the fatigue level of the driver. The method has been designed to work real-time and in continuous operation, by introducing a novel online Exponential Weighted Moving Average (EWMA)-based Bayesian estimation process, which ensures dynamic adaptability to drivers with different physiognomy features, and also to changes due to physiological states (e.g. drowsiness). Our method has been implemented in the framework of a DMS, to take advantage of existing facial landmark detection and tracking mechanisms, and to provide real-time functionality for driving platforms (such as the NVIDIA Drive PX 2). The method is evaluated against a large labelled dataset, and compared to baseline and previous existing methods, showing an excellent balance between adaptability, performance, and robustness.

Poster Session 1 **VEHITS**
16:15 - 17:15 **Room Posters**

Paper #10

Sweat Detection with Thermal Imaging for Automated Climate Control and Individual Thermal Comfort in Vehicles

Diana Schif[1], Ulrich Schwarz[2] and Holger Forst[1]

[1] *BMW AG, Knorrstraße, Munich, Germany*

[2] *Department of Physics, TU Chemnitz, Chemnitz, Germany*

Keywords: Sweat, Perspiration, Thermal Imaging, Thermal Comfort, Vehicle.

Abstract: In addition to autonomous driving, the automation of comfort functions is currently one of the development focuses of the automotive industry. In particular, the automation of the climate function is considered, as manual operation often leads to distraction from the driving task. In order to implement this automation, various data about the vehicle interior and the occupants are needed. Besides interior temperature, gender or air speed, the sweat status of the occupants is relevant. In this work it is examined to what extent the sweat status can be detected with the help of a thermal imaging camera. The aim is to show if it is possible to distinguish the status *not sweating*, *shortly before sweating* and *sweating* using thermal imaging. For this the part of the thermal image showing the forehead is analyzed. More specifically, the difference between minimum and maximum temperature is compared for the different sweat statuses. At an ambient air temperature of 21 °C the thermal comfort level and sweat status of 20 subjects is inquired and skin temperature is measured by a thermal camera during sport activity. Results indicate that there is a significant difference ($p < 0.05$) between status *not sweating* and *shortly before sweating* and also between status *not sweating* and *sweating*. Sweat can therefore be detected with the help of thermal imaging cameras. This result provides important input for automated air conditioning. If sweat is detected for one or more occupants, then with the climate control a corresponding regulation can take place to dry the sweat and to prevent further sweating.

Paper #16

Development and Implementation of a Concept for the Meta Description of Highway Driving Scenarios with Focus on Interactions of Road Users

Raphael Pfeffer, Jingyu He and Sax Eric

Institute for Information Processing Technologies, Karlsruhe Institute of Technology, Engesserstr. 5, Karlsruhe, Germany

Keywords: Automated Driving, Scenario based Testing, Meta Model, Simulation Methods, Scenario Classification.

Abstract: Nowadays reducing the individual risk for advanced driver assistant systems (ADAS) and automated driving while guaranteeing the overall safety on the highway remains a big challenge. The identification of corner test cases and driving scenarios is key in the development process but is still not entirely solved. In the past, many contributed to a unified scenario definition but often with different application focus. In this paper, we develop a new scenario meta model based on existing definitions serving a development and test process where the test data is captured in real (test) drives and its contained scenarios are derived. We present the novelty of our scenario model describing

the behaviour of dynamic objects in highway situations and show a first application of our model and results calculating the uniqueness of scenarios using auto-encoders.

Paper #24

Fuzzy Alarm System based on Human-centered Approach

Elena Magán, Agapito Ledezma, Paz Sesmero and Araceli Sanchis

Computer Science and Engineering Deparment, Universidad Carlos III de Madrid, Av. de la Universidad 30, Leganés (Madrid), Spain

Keywords: ADAS, Advanced Driver Assistance System, Alarm System, Fuzzy Logic, Multi-agent Systems, Ontology.

Abstract: This paper presents an Advanced Driver Assistance System (ADAS), based on a fuzzy logic decision support system and developed by using a multi-agent system. The ADAS is designed so that it can detect dangerous situations on urban environments and alert the driver about them if necessary. For that, it collects data from the car, the car's surroundings and the driver, and represents the information as an OWL ontology. Then, a fuzzy logic inference system uses this information to evaluate whether there is danger or not. The system can detect 9 dangerous situations by using a repository of 14 fuzzy rules, based on a previous work and expanded on this one. Although with limitations, the results show that the ADAS can alert the driver when the driver is in a dangerous situation.

Paper #25

From a Traditional Bicycle to a Mobile Sensor in the Cities

Pedro Nunes, Carlos Nicolau, José Santos and António Completo

Department of Mechanical Engineering, University of Aveiro, Portugal

Keywords: Connectivity Platform, Cloud Services, IoT.

Abstract: The present study focuses on the development of a web cloud based connectivity platform to apply in the context of cycling. One of the main challenges in using bicycle as mean of transportation is related to the cyclists safety and risk perception. In response to that problem, we propose an IoT based module, that will be embedded in the bicycle, allowing sensor data collection and real time sending to the connectivity platform. The data will be used to perceive cyclists route choice preferences, give support to stakeholders either in making new policies to promote bike use or to give cyclist suggestions about the most convenient route, depending on his profile. The main objective is to transform a traditional bicycle into a mobile sensor in the city. The connectivity platform will enable several services, so the bicycle can easily be integrated in a free floating bike-sharing environment.

Paper #36

Towards a Comprehensive Model for the Impact of Traffic Patterns on Air Pollution

Caterina Balzotti[1], Maya Briani[2], Barbara de Filippo[2] and Benedetto Piccoli[3]

[1] *SBAI Department, Sapienza Università di Roma, Rome, Italy*

[2] *Consiglio Nazionale delle Ricerche, Istituto per le Applicazioni del Calcolo M. Picone, Rome, Italy*

[3] *Department of Mathematical Sciences, Rutgers University, Camden, U.S.A.*

Keywords: Road Traffic Modeling, Second Order Traffic Model, Air Pollutant Emissions, Ozone Production.

Abstract: The impact of vehicular traffic on society is huge and multifaceted, including economic, social, health and environmental aspects. The problems is complex and hard to model since it requires to consider traffic patterns, air pollutant emissions, and the chemical reactions and dynamics of pollutants in the low atmosphere. This paper aims at exploring a comprehensive simulation tool ranging from vehicular traffic all the way to environmental impact. As first step in this direction, we couple a traffic second-order model, tuned on NGSIM data, with an nitrogen oxides (NOx) emission model and a set of equations for some of the main chemical reactions behind ozone (O3) production.

Paper #48

Regional Module of Intelligent Transportation System: Algorithms and Information Infrastructure

Anton Sysoev and Elena Khabibullina

Department of Applied Mathematics, Lipetsk State Technical University, Moskovskaya str., 30, Lipetsk, Russia

Keywords: Intelligent Transportation System, Transportation Corridor, Highway Capacity, Data Warehouse Model, Relational Data Model, NoSQL Data Model.

Abstract: Due to the increasing number of personal transportation vehicles and cargo transportation it is reasonable to implement intelligent transportation systems based on adaptive algorithms to deliver the effective control of traffic flows within the highspeed transportation corridors connecting different countries. The presented paper proposed the concept of the regional intelligent transportation system module which could be extented into regions taking into account its specific features. Presented approaches are considered on the data on real-time traffic flow parameters collected from different heterogeneous data sources. The nature of the data and its structure underlie the data warehouse model.

Paper #64

Towards Data-driven Services in Vehicles

Milan Koch[1], Hao Wang[2], Robert Bürgel[1] and Thomas Bäck[2]

[1] *BMW Group, Munich, Germany*

[2] *Leiden University, Leiden, The Netherlands*

Keywords: Data-driven Service, Machine Learning, Damage Prediction, Connected Car, Vehicle Network, Online Learning.

Abstract: Numerous recent studies show the prosperous future of data-driven business models. Some key challenges have to be dealt with when moving towards the development of data-driven car services. In this paper, a new data-driven customer service is proposed for the settlement of vehicle low speed accidents. Beyond that, we present a more general approach towards the development of data-driven car services. We point out its main challenges and suggest a method for developing new customer-oriented data-driven services. This approach illustrates key points in developing a practical service, from a technical and business related perspective. Such data-driven services are developed mostly on a small number of initial test data, which results often in a limited prediction performance. Therefore, based on an optimized CRISP-DM approach, we propose a methodology for developing initial prediction models with limited test data and stabilizing the models with newly gained data after deployment by online learning. On-board and off-board services are discussed with the result that especially off-board running services offer a large potential for future data-driven business models in a digital ecosystem. The flexibility of such an ecosystem depends on the degree of the integration of the vehicle in the ecosystem - in other words, the car needs to be enabled to deliver data on demand according to GDPR and to any applicable regional law and in cooperation with the customer. The presented method, together with the ecosystem, enables fast developments of various data-driven services.

Paper #66

Integration of Voice Assistant and SmartDeviceLink to Control Vehicle Ambient Environment

Ayush Shah[1] and Anastacia Gusikhin[2]

[1] *Ford Research and Advanced Engineering, Dearborn, MI, U.S.A.*

[2] *University of Michigan, Ann Arbor, MI, U.S.A.*

Keywords: Personal Voice Assistant, Connected Vehicles, Ambient Intelligence, Amazon Alexa, Voice Skills, SmartDeviceLink.

Abstract: Over the past few years, the popularity of personal voice assistants has grown, particularly for use in the vehicle environment where voice is a preferred mode of interface to minimize driving distractions. Amazon Alexa, one of the most popular voice assistants, has been integrated in many vehicle brands. While existing Alexa car applications provide vehicle occupants with access to a multitude of voice skills in infotainment and smart home control, these applications lack the capability to manage the vehicle's ambient environment. This paper discusses an efficient and effective integration of Amazon Alexa with vehicle climate control, potentially augmented with brought-in devices, using SmartDeviceLink API. The paper overviews the architecture, Alexa skill development, and examples of dialogue. We also present the results of a customer evaluation of the presented system and directions for future research and development toward Ambient Intelligence.

Session 3A **VEHITS**
17:15 - 18:15 **Room 4**
Autonomous Vehicles and Automated Driving

Paper #38

Dynamic Control System Design for Autonomous Car

Shoaib Azam, Farzeen Munir and Moongu Jeon

School of Electrical Engineering and Computer Science, Gwangju Institute of Science and Technology, Gwangju, South Korea

Keywords: Longitudinal Control, Lateral Control, Model Predictive Control, Pure Pursuit.

Abstract: The autonomous vehicle requires higher standards of safety to maneuver in a complex environment. We focus on control of the self-driving vehicle that includes the longitudinal and lateral dynamics of the vehicle. In this work, we have developed a customized controller for our KIA Soul self-driving car. The customized controller implements the PID control for throttle, brake, and steering so that the vehicle follows the desired velocity profile, which enables a comfortable and safe ride. Besides, we have also catered the lateral dynamic model with two approaches: pure pursuit and model predictive control. An extensive analysis is performed between pure pursuit and its adversary model predictive control for the efficacy of the lateral model.

Paper #41

Advanced Curve Speed Warning System using Standard GPS Technology and Road-level Mapping Information

Shahnewaz Chowdhury, Muhammad Faizan and M. Hayee

Department of Electrical Engineering, University of Minnesota Duluth, Duluth, MN 55812, U.S.A.

Keywords: Advance Curve Warning System, Super-elevation, Friction Factor, Advisory Speed Limit.

Abstract: Lane departure and advance curve warning are critical among several Advanced Driver-Assistance Systems (ADAS) functions, which have significant potential to reduce crashes. Generally, lane departure and advance curve speed warning systems either use different image processing techniques or GPS technology with digital maps of lane-level resolution. However, these systems are expensive to implement as well as have some limitations such as harsh weather or irregular lane markings can negatively influence their performance. Previously we proposed a lane departure detection which uses a standard GPS receiver without any lane-level resolution maps. Now, we have added another feature in this algorithm to detect an upcoming curve in advance and warn the driver about its advisory speed at a safe distance so that driver can adjust vehicle speed accordingly before reaching the curve. We have implemented our algorithm in a prototype system and demonstrated in the field. We have performed extensive field tests and the test results show that each time vehicle approaches a curve, our algorithm issues a warning and correctly determines the advisory speed for the curve to warn the driver at a safe distance before the curve starts.

Paper #43

Are Consumers Ready to Adopt Highly Automated Passenger Vehicles? Results from a Cross-national Survey in Europe

Ilias Panagiotopoulos[1], George Dimitrakopoulos[1], Gabrielė Keraitė[2] and Urte Steikuniene[2]

[1] *Department of Informatics and Telematics, Harokopio University, Athens, Greece*

[2] *Metis Baltic, Vilnus, Lithuania*

Keywords: Highly Automated Passenger Vehicles, Consumer's Intention to Adopt, Technology Acceptance, Perceived Driving Enjoyment, Perceived Financial Cost, Perceived Reliability/Trust.

Abstract: Automated vehicles are currently being developed by major car manufacturers planning to be available in market diffusion the next years. This disruptive technology is expected to provide an alternative type of transportation services by positively affecting road safety, traffic congestion, more individual comfort and convenience for drivers/users. However, besides the aforementioned societal benefits, researches on the predictors influencing individuals' attitudes and willingness to adopt automated vehicles in the future are crucial requirements for their successful diffusion in international market. In this way, the current study aims to investigate the factors that may hinder or facilitate consumers' acceptance and adoption of Highly Automated Passenger Vehicles (HAPVs). A research model through extending the original Unified Theory of Acceptance and Use of Technology (UTAUT) was developed and accordingly an online survey was conducted among the general public in Europe; 811 valid answers were collected and analyzed. The results indicate that the constructs of perceived driving enjoyment, perceived financial cost, perceived reliability/trust, social influence and performance expectancy were all useful predictors of behavioural intentions to drive/use HAPVs. The findings derived from this study will contribute to car manufacturers towards HAPVs in order not only to develop better driving automation technology systems for them, but also to develop proper implementation strategies that will lead to widespread deployment in international market.

Session 3B **VEHITS**
17:15 - 18:15 **Room 5**
Information Systems and Technologies

Paper #12

A Vehicle Telematics Service for Driving Style Detection: Implementation and Privacy Challenges

Christian Kaiser[1], Alexander Stocker[1], Andreas Festl[1], Marija Petrovic[1], Efi Papatheocharous[2], Anders Wallberg[2], Gonzalo Ezquerro[3], Jordi Orbe[3], Tom Szilagyi[4] and Michael Fellmann[4]

[1] *Virtual Vehicle Research GmbH, Graz, Austria*

[2] *RISE (Research Institutes of Sweden), Kista, Sweden*

[3] *JIG, Logroño, Spain*

[4] *University of Rostock, Rostock, Germany*

Keywords: Automotive, Connected Vehicles, Data-driven Services, Vehicle Telematics Service, Privacy, Trust, Cloud Computing, Mobile Driver Application, Quantified Vehicles.

Abstract: Connected mobility is not only a future market, but also holds great innovation potential. The analysis of vehicle telematics data in the cloud enables novel data-driven services for several stakeholders, e.g. a mobile application for the driver to obtain his driving style. This inevitably leads to privacy concerns and the question why and when are users willing to share driving telematic data, which we addressed in an empirical study. The paper presents an implementation of a data-driven service based on vehicle telematics data and discusses how privacy issues can be tackled. For the data-driven service, the most interesting steps along the vehicle data value chain are described in detail, firstly (i) vehicle telematics data collection, secondly, (ii) the wireless data transfer to a cloud platform, and thirdly, (iii) pre-processing and data analysis to evaluate the drivers' driving style and analyse the driving risk. Finally, (iv) a smartphone application for drivers presents driving style and driving risk data on the smartphone in an interactive way, so that the driver can work on improving both, which has a positive effect on driving and road safety.

Paper #29

A Data Driven Approach to Derive Traffic Intersection Geography using High Resolution Controller Logs

Dhruv Mahajan, Tania Banerjee, Yashaswi Karnati, An. Rangarajan and Sanjay Ranka

Department of Computer and Information Science and Engineering, University of Florida, Gainesville, FL, U.S.A.

Keywords: Loop Detectors Systems, ATSPM, Controller Logs, Detector Mappings, Detector Configuration, Data Mining.

Abstract: Current traffic signal controllers are capable of recording events (signal events; vehicle arrival and departure) at very high resolutions (usually, 10Hz). The high resolution data rates enable the computation and study of various (granular) measures of effectiveness. However, without knowing the location of specific detectors on an intersection and the phases they are mapped to, a number of measures of effectiveness (of signal performance) cannot be evaluated. These mappings may not be available or up to date for many practical reasons (e.g., old infrastructure, mappings not machine readable, maintenance or addition of new lanes, etc.). In this paper, we develop an inference engine to map detectors to phases and distinguish between the stop bar and advance detectors, or in other words, infer the location of the loop detectors with reference to the intersection.

Paper #34

A Lightweight Virtualisation Platform for Cooperative, Connected and Automated Mobility

Fabian Gand, Ilenia Fronza, Nabil El Ioini, Hamid Barzegar, Van Le and Claus Pahl

Free University of Bozen-Bolzano, Bolzano, Italy

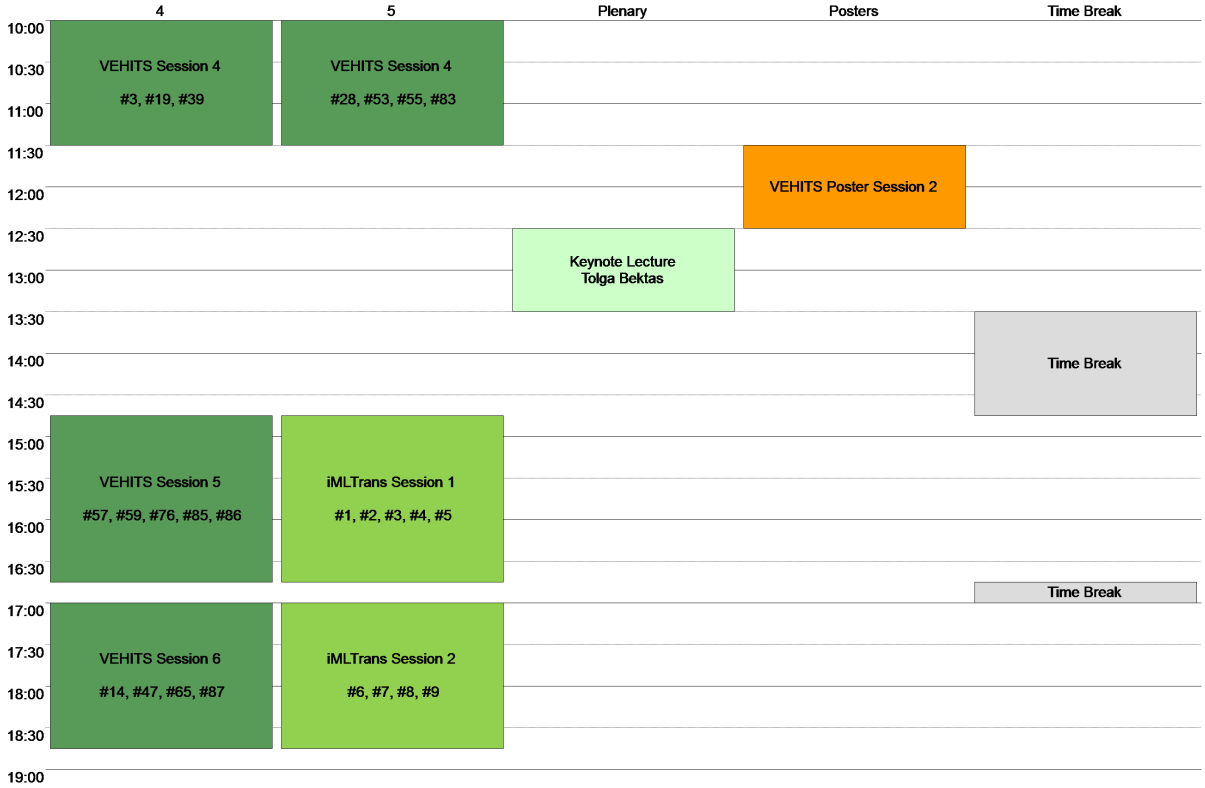
Keywords: Digital Mobility, CCAM, Road Mobility, Edge Cloud, Container, Orchestration, Performance Engineering.

Abstract: Digital mobility systems such as autonomous cars or traffic management build on connectivity and automated cooperation. In order to facilitate various use cases such as vehicle manoeuvres, infotainment support or state share functions, a distributed layered computation and communication infrastructure is needed that connects vehicles and other devices through mobile networks, linking them to edge and cloud services. Of particular relevance are lightweight clustered infrastructures close to the edge of the network that provide nonetheless sufficient compute, storage and networking capabilities. Clusters consisting

of single-board devices are used in a variety of these use cases. In most cases, data that is accumulated on the devices has to be sent to remote cloud hubs for processing. However, with the hardware capabilities of these controllers continuously increasing, it is now possible to directly process data on these edge cluster. This concept is known as Edge Computing. We propose an edge computing architecture for cooperative, connected and automated mobility that relies on industry-standard technologies such as the MQTT protocol for communication, Prometheus for monitoring and Docker swarm in conjunction with openFaas for deploying containerized services.

Sunday Sessions: May 3

Sunday Sessions: May 3 Program Layout



Session 4A **VEHITS**
10:00 - 11:30 **Room 4**
Traffic and Vehicle Data Collection and Processing

Paper #3

Use Case of Quay Crane Container Handling Operations Monitoring using ICT to Detect Abnormalities in Operator Actions

Sergej Jakovlev[1,2], Tomas Eglynas[1], Mindaugas Jusis[1,3], Saulius Gudas[3], Valdas Jankunas[1] and Miroslav Voznak[2]

[1] *Klaipeda University, Bijunu str. 17 – 206, Klaipeda, Lithuania*

[2] *VŠB-Technical University of Ostrava, 17, Listopadu 15, 708 33, Ostrava-Poruba, Czech Republic*

[3] *Vilnius University, Akademijos str. 4, LT-04812 Vilnius, Lithuania*

Keywords: Data Acquisition, Communication Technology, Engineering, Systems Design.

Abstract: This paper presents the initial research findings from the Klaipeda port monitoring action related to Blue economy development initiative in the Baltic Sea. Use case study demonstrates the possibility to address the problem of information system deployment in harsh industrial environment to gather valuable statistical knowledge. Custom made monitoring and data transmission units were developed to utilize the best practice of engineering to solve real problems of Klaipeda Port. Several key operations and parameters were monitored during the research, including containers spreader movements, physical characteristics of the cables, metal constructions. Initial results suggested that crane operators' involvement in the control of the cargo movement produced incorrect control patterns (joystick movements) that delayed port operations. Each control movement of the joystick needs to have a direct real-time feedback from the spreader (actual movement of the cargo). Feedback control functionality will allow adjusting the spreader movement according to the operator and will decrease the cargo transportation time during constant breaks.

Paper #19

Detection and Recognition of Arrow Traffic Signals using a Two-stage Neural Network Structure

Tien-Wen Yeh[1] and Huei-Yung Lin[2]

[1] *Department of Electrical Engineering, National Chung Cheng University, Chiayi 621, Taiwan*

[2] *Department of Electrical Engineering and Advanced Institute of Manufacturing with High-tech Innovations National Chung Cheng University, Chiayi 621, Taiwan*

Keywords: Traffic Light Detection, Traffic Light Recognition, Arrow Traffic Signal.

Abstract: This paper develops a traffic light detection and recognition system based on convolutional neural networks for Taiwan road scenes. A two-stage approach is proposed with first detecting the traffic light position, followed by the light state recognition. It is specifically designed to identify the challenging arrow signal lights in many urban traffic scenes. In the detection stage, the map information and two cameras with different focal lengths are used to detect the traffic lights at different distances. In the recognition stage, a new method combining object detection and classification is proposed to deal with various light state classes in Taiwan road scenes. Furthermore, an end-to-end network with shared feature maps is implemented to reduce the computation time. Experiments are carried out on the public LISA dataset and our own dataset collected from two routes with urban traffic scenes.

Paper #39

Video-based Machine Learning System for Commodity Classification

Pan He, Aotian Wu, Xiaohui Huang, Anand Rangarajan and Sanjay Ranka

Department of Computer and Information Science and Engineering, University of Florida, U.S.A

Keywords: Truck and Trailer Classification, Deep Learning, Intelligent Transportation Systems.

Abstract: The cost of video cameras is decreasing rapidly while their resolution is improving. This makes them useful for a number of transportation applications. In this paper, we present an approach to commodity classification from surveillance videos by utilizing text information of logos on trucks. A new real-world benchmark dataset is collected and annotated accordingly that covers over 4,000 truck images. Our approach is evaluated on video data collected in collaboration with the state transportation entity. Results on this dataset indicate that our proposed approach achieved promising performance. This, along with prior work on trailer classification, can be effectively used for automatically deriving the commodity classification for trucks moving on highways using video collection and processing.

Session 4B **VEHITS**
10:00 - 11:30 **Room 5**
Autonomous Vehicles and Automated Driving

Paper #28

Weather Effects on Obstacle Detection for Autonomous Car

Rui Song[1], Jon Wetherall[2], Simon Maskell[1] and Jason Ralph[1]

[1] *Dept. Electrical Engineering and Electronics University of Liverpool Liverpool, U.K.*

[2] *CGA Simulation, Liverpool, U.K.*

Keywords: Autonomous Vehicle, Multiple Sensors, Weather Simulation, Virtual Environment, Object Detection.

Abstract: Adverse weather conditions have become a critical issue when developing autonomous vehicles and driver assistance systems. Training and testing autonomous vehicles in a simulation environment before deploying them into the market have many benefits due to lower costs and fewer risks. However, there are only a few works about weather influences on sensors in the simulated environment. A more systematic study of weather effects on the sensors used on autonomous cars is required. This paper presents a multi-sensor simulation environment under different weather conditions and examines the influence on environmental perception and obstacle detection for autonomous cars. The simulation system is being developed as part of a collaborative project entitled: Artificial Learning Environment for Autonomous Driving (ALEAD). The system incorporates a suite of sensors typically used for autonomous cars. Each sensor model has been developed to be as realistic as possible – incorporating physical defects and other artefacts found in real sensors. The influence of weather on these sensors has been simulated based on experimental data. The multi-sensor system has been tested under different simulated weather conditions and analysed to determine the effect on detection of a dynamic obstacle and a road lane in a 3D environment.

Paper #53

Auto-Sapiens Autonomous Driving Vehicle

Maicol Laurenza, Gianluca Pepe and Antonio Carcaterra
Department of Mechanical and Aerospace Engineering of Sapienza University of Rome, Italy

Keywords: Autonomous Car, Collision Avoidance, Velocity Obstacle, Optimal Feedback Control.

Abstract: This paper presents the Auto-Sapiens project, an autonomous driving car developed by the Mechatronics and Vehicle Dynamics Lab, at Sapienza University of Rome. Auto-Sapiens is a technological platform to test and improve innovative control algorithms. The car platform is a standard car (Smart ForTwo) equipped with throttle, brake, steering actuators and different sensors for attitude identification and environment reconstruction. The first experiments of the Auto-Sapiens car test a new obstacle avoidance. The vehicle, controlled by an optimal variational feedback control, recently developed by the authors, includes the nonlinearities inherent in the car dynamics for better performances. Results show the effectiveness of the system in terms of safety and robustness of the avoidance maneuvers.

Paper #55

An Optimization-based Strategy for Shared Autonomous Vehicle Fleet Repositioning

Felipe de Souza[1], Krishna Gurumurthy[2], Joshua Auld[1] and Kara Kockelman[2]
[1] *Argonne National Laboratory, 9700 Cass Avenue, Lemont, IL, U.S.A.*
[2] *Department of Civil, Architectural and Environmental Engineering, University of Texas at Austin, Austin, TX, U.S.A.*

Keywords: Shared Autonomous Vehicles, Repositioning, Agent-based Simulation, POLARIS, Bloomington.

Abstract: With the emergence of autonomous technology, shared autonomous vehicles (SAVs) will potentially be the prevalent transportation mode for urban mobility. On one hand, relying on SAV fleets can provide several operational benefits. On the other hand, SAVs can increase travel distance and add congestion due to unoccupied trips such as pickup and repositioning trips. One important aspect for a SAV fleet's success is to serve the incoming requests at reasonably low waiting time. This is achieved by an adequate fleet size that is spatially distributed thoughtfully so that incoming requests can be served by a nearby vehicle. Unfortunately, it is challenging to keep a satisfactory spatial distribution of vehicles due to imbalances in the origin and destination patterns of incoming requests. This paper focuses on the impact of SAV relocation on traveler wait times using a novel optimization-based algorithm for repositioning. POLARIS, an agent-based tool, is used for a case study of Bloomington, Illinois to quantify the benefits of allowing SAV repositioning. On average, the wait times were around 20% lower with repositioning for all adequate fleet sizes. SAVs were available more uniformly across the region's zones, and proportional to trip-making at different times of day. In addition, enabling repositioning led to a higher share of demands being served. These benefits, however, are achieved at the expense of 6% added vehicles miles traveled.

Paper #83

What Cooperation Costs: Quality of Communication and Cooperation Costs for Cooperative Vehicular Maneuvering in Large-scale Scenarios

Daniel Bischoff[1,2], Florian Schiegg[3], Tobias Meuser[2], Dieter Schuller[1], Nils Dycke[2] and Ralf Steinmetz[2]
[1] *Active Safety Advanced Technology, Opel Automobile GmbH, Rüsselsheim, Germany*
[2] *Multimedia Communications Lab (KOM), TU Darmstadt, Germany*
[3] *Corporate Research, Robert Bosch GmbH, Hildesheim, Germany*

Keywords: V2X, Cooperative Vehicular Maneuvering, MCM, Intersection, Quality of Communication, Cooperation Cost.

Abstract: With the rise of vehicles on the road, Cooperative Vehicular Maneuvering (CVM) is a crucial prospect to increase the efficiency of future vehicular traffic. Recent work proposes promising approaches for CVM using Vehicle-to-Everything (V2X) communication to increase traffic efficiency but evaluates its performance with only a few vehicles involved and without considering realistic radio propagation channel models. CVM relies on high quality of communication to coordinate cooperative maneuvers and increases traffic efficiency primarily under heavy vehicular traffic load, which also challenges the V2X quality of communication in terms of channel load and reliability. In this paper, we propose a novel computational efficient CVM planning algorithm specially designed for large-scale scenarios considering a realistic radio propagation channel model and analyze the quality of communication and cooperation cost of CVM using ad hoc communication technology. For our urban intersection scenario, we show that imperfect communication limits the earliest start of cooperation to 150 m and increases the average Age of Information (AoI) of CVM messages up to 400 ms, which motivates the need for more advanced V2X dissemination strategies

Poster Session 2 **VEHITS**
11:30 - 12:30 **Room Posters**

Paper #61

Map Attribute Validation using Historic Floating Car Data and Anomaly Detection Techniques

Carl Esselborn[1], Leo Misera[1], Michael Eckert[1], Marc Holzäpfel[1] and Eric Sax[2]
[1] *Dr. Ing. h.c. F. Porsche AG, Weissach, Germany*
[2] *Department of Electrical Engineering, Karlsruhe Institute of Technology, Karlsruhe, Germany*

Keywords: Map Data, Validation, Floating Car Data, Anomaly Detection, Autoencoder, Yield Signs.

Abstract: Map data is commonly used as input for Advanced Driver Assistance Systems (ADAS) and Automated Driving (AD) functions. While most hardware and software components are not changed after releasing the system to the customer, map data are often updated on a regular basis. Since the map information can have a significant influence on the function's behavior, we identified the need to be able to evaluate the function's performance with updated map data. In this work, we propose a novel approach for map data regression tests in order to evaluate specific map features using a database of historic floating car data (FCD) as a reference. We use anomaly detection methods to identify situations in which floating car data and map data do

not fit together. As proof of concept, we applied this approach to a specific use case finding yield signs in the map, which are currently not present in the real world. For this anomaly detection task, the autoencoder shows a high precision of 90% while maintaining an estimated recall of 45%.

Paper #67

Safety and Dependability of Autonomous Systems in Container Terminals: Challenges and Research Directions

Eetu Heikkilä, Timo Malm, Risto Tiusanen and Toni Ahonen

VTT Technical Research Centre of Finland Ltd., Tampere, Finland

Keywords: Autonomous Port, Autonomous Systems, Container Logistics.

Abstract: Increasing use of autonomous machine systems is a major trend in port logistics, especially in container handling. Over the past decades, large seaports have automated parts of their operations. Currently, also smaller ports are looking to apply automated and autonomous solutions. This is expected to increase efficiency and safety, but also to introduce new mixed-traffic situations between humans, manual machines and machines of different levels of autonomy. This is likely to introduce safety risks and dependability challenges for system development and operation. In this paper, we discuss selected key challenges that need to be solved to ensure that autonomous container handling solutions can be implemented safely and profitably. We also present topical research directions that are planned and ongoing to solve these challenges.

Paper #68

Towards Digitalized and Automated Work Processes in Port Environments

Toni Ahonen, Helena Kortelainen and Antti Rantala

VTT Technical Research Centre of Finland, Visiokatu 4, Tampere, Finland

Keywords: Automation, Digitalization, Container Terminal, Port.

Abstract: Requirements for safety and productivity in container terminal processes are the key drivers for automation and digitalized processes. While automation development has so far been focused on large terminal environments and introduction of smart port concepts and utilization of digital technologies are to large extent limited to megaports and forerunners, there is an increasing interest in implementing automation and digitalization at smaller ports in profitable manner. Current paper discusses the enablers and barriers of automation and digital services at such ports, presents a framework for customer value in the contexts and outlines focal development targets.

Paper #73

Case Study: Regulation of Noise Produced by a Rotary-screw Propulsion Unit in an All-terrain Vehicle

Umar Vahidov, Alexander Belyaev, Vladimir Makarov, Vladimir Makarov, Dmitriy Mokerov and Yuri Molev

Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Minin St., 24, Nizhny Novgorod, Russian Federation

Keywords: Rotary-screw Propulsion Unit, Ice, Interaction, Noise Level.

Abstract: The study presents methods developed to calculate permissible level of acoustic radiation produced by a rotary-screw propulsion unit on ice. The study is based on the papers of the researchers who studied acoustic waves generated by construction and road vehicles. The authors of the study applied the aforementioned theories to the case of interaction between a rotary-screw propulsion unit and ice. The paper provides general measuring methods and evaluates how every type of interaction between propulsion unit components and ice affects overall level of generated acoustic pressure. The results and conclusions obtained during the research can be used to help manufacturers select the parameters of the rotary-screw propulsion unit which contribute to reduction of noise inside the cabin of an all-terrain vehicle.

Paper #89

Experimental Theoretical Study of the Mobile Robotic System Movement with Caterpillar-modular Propulsion on the Beach Line Terrain

Alexander Belyaev[1], Alexey Papunin[1], Evgeny Zharkov[2], Alexey Vasiliev[1], Vladimir Belyakov[1] and Vladimir Makarov[1]

[1] *Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Minin St., 24, Nizhny Novgorod, Russian Federation*

[2] *GAZ Group's United Engineering Center, Nizhny Novgorod, Russian Federation*

Keywords: AMRC, Modeling, Caterpillar-modular Propulsion, Beach Line Terrain, Adams, ATV, Unmanned Ground Vehicles.

Abstract: This article presents the data for mobile robotic system motion modeling with caterpillar-modular propulsion on the sand support base. The study provides the basics of the development of the calculation model in Adams Tracked Vehicle amid mass and geometric chassis parameters and characteristics of nonrigid soil. The study presents the 3D views of the model created. The study provides the fragments of curvilinear motion. The study provides graphs of behavior moments for chassis beads, as well as shows the total resistance to motion on sandy beach. The mean of the moment on one bead during linear motion amounted to 172 Nm, during curvilinear 195 and 217 Nm respectively for backward and overleaping chassis beads. The mean resistance to motion during linear motion amounted to 1606 N, during curvilinear to 1943 N. To validate the results of the modeling we have conducted experimental studies.

Poster Session 2	iMLTrans
11:30 - 12:30	Room Posters

Paper #10

Ways to Improve the Efficiency of the Truck's Branded Service System

K. Shubenkova, P. Buyvol, I. Makarova and L. Gabsalikhova

Kazan Federal University, 68/19 Mira Avenue, Naberezhnye Chelny, Russia

Keywords: Branded Service System, Dealer Service Center, Simulation Model, Statistical Data Analysis.

Abstract: The article discusses ways to improve the trucks maintenance efficiency. It is shown that only integrated solutions will optimize the activities of the automotive corporation's branded service system (BSS). The best solution in this situation is a decision support system (DSS) with an open architecture. The proposed methodology is aimed at improving the maintenance and repair system while expanding markets. Examples of developed modules applying as part of DSS, such as statistical data analysis and simulation models, are shown.

Paper #11

Investigating the Influence of Emotional Intelligence on the Supplier Selection Decisions with Fuzzy Cognitive Maps

Maria Drakaki[1], Panagiotis Tzionas[2] and Kuanysh Abeshev[3]

[1] *Department of Science and Technology, University Center of International Programmes of Studies, International Hellenic University, 14th km Thessaloniki -N.Moudania, GR-57001, Thermi, Greece*

[2] *Department of Industrial Engineering and Management, International Hellenic University, P.O. Box 141, GR-57400, Thessaloniki, Greece*

[3] *School of Engineering Management, Almaty Management University, Rozybakiyeva st., 227, 050060, Almaty, Kazakhstan*

Keywords: Supplier Selection, Sustainability, Fuzzy Cognitive Maps, Supply Chain Risks, Emotional İntelligence.

Abstract: Supplier selection holds a strategic role in supply chain management. Multi-criteria decision making methods combined with fuzzy and intelligent approaches have been primarily used to solve supplier selection problems considering sustainability and risk factors. Yet sustainability criteria as well as risk factors proposed in the literature vary, as well as the assigned weight values that measure the relative importance of the various criteria and risks. Moreover, human decisions involve emotions. Therefore, it would be useful to identify potential causal relationships between criteria and risk factors and emotional intelligence of decision makers, in order to identify potential biases in the decision making process. In particular, trust and relationship building with the suppliers may affect the emotional intelligence of decision makers. For this purpose, in this paper a methodology which uses Fuzzy Cognitive Maps is presented, in order to investigate by simulation, different scenarios that could identify the influence of emotional intelligence of the decision makers regarding the supplier selection problem.

Keynote Lecture	VEHITS
12:30 - 13:30	Room Plenary

Last-Mile Logistics in Urban Areas

Tolga Bektas

University of Liverpool Management School, U.K.

Abstract: Freight transport makes up 16% of all road vehicle activity in UK cities, with lorries and vans performing 30% of their total activity in urban areas. Around 2.4 billion parcels were sent in the UK in 2017-18, for example, giving rise to significant operational challenges in performing last-mile deliveries. In this talk, I will present some of the findings of the research project titled FTC2050: Freight Traffic Control 2050 (http://www.ftc2050.com) that looked at the collective transport and energy impacts of current 'business-as-usual' carrier activities in London. The aim was to improve carrier collection and delivery schedules by investigating the potential of new business models for reducing localised transport impacts. I will describe the practical challenges faced by last-mile logistics operators, and present alternative distribution models in the way of improving the overall efficiency of the operations.

Time Break	VEHITS
13:30 - 14:45	Room Time Break

Session 5A	VEHITS
14:45 - 16:45	Room 4
Big Data & Vehicle Analytics	

Paper #57

Clustering Object Trajectories for Intersection Traffic Analysis

Tania Banerjee, Xiaohui Huang, Ke Chen, Anand Rangarajan and Sanjay Ranka

CISE, University of Florida, Gainesville, Florida, U.S.A.

Keywords: Intersection Traffic Analysis, Trajectory Data Mining, Anomaly Detection.

Abstract: Vehicle and pedestrian traffic at a traffic intersection provide crucial information about the performance of the intersection for safety and throughput. It is possible to discover patterns and outliers on this data by applying data analytics. In this paper, we present a novel clustering algorithm for trajectories that use a new distance measure and a two-level hierarchical clustering approach based on geometric properties of the trajectories and spectral clustering. Trajectory data is augmented with signal phasing and timing information, which gives new insights to the trajectory data. We demonstrate the procedure on a real-life intersection where the prominent patterns for traffic movement are found, and the anomalous trajectories are extracted.

Paper #59

Qualitative Feature Assessment for Longitudinal and Lateral Control-features

Jacob Langner[1], Christian Seiffer[1], Stefan Otten[1], Kai-Lukas Bauer[2], Marc Holzäpfel[2] and Eric Sax[1]

[1] *FZI Research Center for Information Technology, 76131 Karlsruhe, Germany*

[2] *Dr. Ing. h.c. F. Porsche AG, 71287 Weissach, Germany*

Keywords: Qualitative Feature Assessment, Representativity, Test Coverage, Data Analytics, Real-World-Driving-Data.

Abstract: Control features take over a multitude of driving tasks in today's vehicles. The complexity of the underlying software code and control parameters has grown to a staggering size. It is no longer viable to test and evaluate features on a pure feature level while driving through real world traffic. The driving tasks and environmental situations are too manifold to be lumped together undifferentiated. As time and resources during development are scarce, test scopes are limited. However, test coverage and representativity are crucially important and can not be neglected. We propose an approach that enables feature evaluation on a driving task basis and achieves holistic assertions for the maturity level even on small test scopes. The approach is based on recorded road tests and is demonstrated with a brief example.

Paper #76

Temporal Network Approach to Explore Bike Sharing Usage Patterns

Aizhan Tlebaldinova[1], Aliya Nugumanova[1], Yerzhan Baiburin[1], Zheniskul Zhantassova[2], Markhaba Karmenova[2] and Andrey Ivanov[3]

[1] *Laboratory of Digital Technologies and Modeling, S. Amanzholov East Kazakhstan State University, Shakarim Street, Ust-Kamenogorsk, Kazakhstan*

[2] *Department of Computer Modeling and Information Technologies, S. Amanzholov East Kazakhstan State University, Shakarim Street, Ust-Kamenogorsk, Kazakhstan*

[3] *JSC »Bipek Auto« Kazakhstan, Bazhov Street, Ust-Kamenogorsk, Kazakhstan*

Keywords: Bike Sharing, Temporal Network, Betweenness Centrality, Clustering, Time Series.

Abstract: The bike-sharing systems have been attracting increase research attention due to their great potential in developing smart and green cities. On the other hand, the mathematical aspects of their design and operation generate a lot of interesting challenges for researchers in the field of modeling, optimization and data mining. The mathematical apparatus that can be used to study bike sharing systems is not limited only to optimization methods, space-time analysis or predictive analytics. In this paper, we use temporal network methodology to identify stable trends and patterns in the operation of the bike sharing system using one of the largest bike-sharing framework CitiBike NYC as an example.

Paper #85

Developing a Traffic Congestion Model based on Google Traffic Data: A Case Study in Ecuador

Yasmany García-Ramírez

Department of Civil Engineering, Universidad Técnica Particular de Loja, San Cayetano Street, Loja, Ecuador

Keywords: Urban Streets, Developing Countries, Traffic Congestion Model, Fundamental Parameters, Google.

Abstract: Congestion on urban streets has negative impacts on the urban economy, environment, and lifestyle. Congestion, in developing countries, will increase despite knowing its cons. One way to control or reduce congestion is by sharing traffic information through traffic model congestion. This model includes the estimation of the travel time from the desired place of origin-destination. Speed-flow-density parameters help to calculate travel time. These fundamental parameters could be estimated using Floating Car Data from Google. Therefore, the objective of this research is to calibrate equations for the fundamental parameters with traffic state indicators by Google, relating them to ground truth data. Six density-flow equations and six speed-density equations were calibrated using power and linear curve, and some of them were validated. Other cities can use these equations to build their traffic congestion model. With this model, road users can plan the journey and choice the best route or travel in times of low congestion or uptake of public transport, decongesting the city and saving traffic costs related. This comprehensive research extends the knowledge of how Google traffic information can employ in developing cities.

Paper #86

New Traffic Congestion Analysis Method in Developing Countries (India)

Tsutomu Tsuboi

Global Business Development, Nagoya Electric Works Co., Ltd., 29-1 Mentoku Shinoda, Ama Aichi, Japan

Keywords: Traffic Flow, Traffic Density, Traffic Congestion.

Abstract: This manuscript describes introducing new traffic congestion analysis for developing country in India. In generally, it is challenge to show how traffic congestion occurs, especially in developing countries such as in India because its traffic is consisted of various kinds of transportation like two wheelers, three wheelers, and sometimes animals on the roads. There is a chance to collect real traffic flow data in Ahmedabad of Gujarat states of India since October 2014. The traffic monitoring system there consist of 14 traffic monitoring cameras and the system is capable to monitor traffic density, traffic volume, average vehicle speed, and occupancy at the each location. In this manuscript, there are three types of traffic congestion analysis. One is based on its observation traffic flow, in which it compares daily traffic volume and its average vehicle speed. The second one is based on the judgement of occupancy parameter, which uses as one of traffic congestion parameter in general. The third one is based on estimation from "social loss" calculation which comes from the traffic flow theory but is challenge to analyse in the developing countries. The social loss calculation is proven in the traffic theory but it is difficult to define the traffic demand curve, the social cost curve, and the traffic supply curve. Author shows how to make the practical "social loss" calculation and its validation compared with the actual traffic congestion condition.

Special Session - Session 1 **iMLTrans**
14:45 - 16:45 **Room 5**
Intelligent Mobility, Logistics and Transport

Paper #2

Legal Regulation Problems by using Highly Automated Vehicles

R. Magizov, L. Gabsalikhova, T. Nikolaev and V. Mavrin
Kazan Federal University, Suyumbike Avenue, 10A, Naberezhnue Chelny, Russia

Keywords: Highly Automated Vehicles, Legal Regulation.

Abstract: The application of new technologies in the design of modern cars has gradually led to the automation of various control processes. Today, the legal systems of different countries are faced with the problem of regulating the use of highly automated road transport. Such a vehicle may fulfill part of the functions of the driver or even, potentially, replace it completely. Different approaches to the problem of regulation give rise to different solutions. The presented article is devoted to the problems of legal regulation of the operation of highly automated cars. The problems of terminology are touched on, approaches to legal regulation in this area in different states are described. It is concluded that currently in Russia the legal basis for the use of unmanned vehicles has not yet been fully formed and there are a number of issues that need to be regulated. Based on the study, the author formulates proposals for amendments and additions to the legislation of the Russian Federation related to the operation of highly automated cars.

Paper #3

Responsibility for Causing Harm as a Result of a Road Accident Involving a Highly Automated Vehicle

R. Magizov, E. Mukhametdinov and V. Mavrin
Kazan Federal University, Suyumbike Avenue, 10A, Naberezhnue Chelny, Russia

Keywords: Highly Automated Vehicles, Road Accident, Responsibility for Causing Harm.

Abstract: The development and implementation of highly automated transport (unmanned vehicles) is accompanied by a number of problems, including problems related to liability for accidents and causing harm involving unmanned vehicles. The indicated problem faces the legislators and the public of all countries where highly automated transport is produced, tested and introduced. A number of countries have already made an attempt to legislatively regulate issues related to the production of highly automated and unmanned vehicles, their operation and liability for damage. In the presented article, an analysis of the current legislation of the regulatory framework and the conditions for prosecution for damage caused by a highly automated vehicle as a result of a traffic accident, as well as an analysis of the positions of the authors on the topic under study, is carried out. Based on the study, the author formulates proposals on the need for amendments and additions to the current legislation of the Russian Federation related to fixing the grounds and conditions for holding liable, as well as determining the range of subjects to be liable for damage caused by a highly automated vehicle.

Paper #4

Association Rules to Identify Factors Affecting Risk and Severity of Road Accidents

Irina Makarova[1], Gulnara Yakupova[1], Polina Buyvol[1], Eduard Mukhametdinov[1] and Anton Pashkevich[2]
[1] *Kazan Federal University, Syuyumbike prosp., 10a, 423822 Naberezhnye Chelny, Russian Federation*
[2] *Politechnika Krakowska, Warszawska st., 24, Krakow, Poland*

Keywords: Accidents, Association Rules, Factors, Safety, Severity of Consequences, Vehicles.

Abstract: The current increase in automobilization leads to a decrease in road safety. Therefore, the purpose of this research is to analyze and identify the causes that significantly affect the risk and severity of accidents. For this purpose, both histograms plotting and association rules were used. The statistics of traffic accidents in Elabuga town for 2017-2018 were taken as initial information. To identify the most traumatic types of traffic accidents, graphs of the number of accidents by types of accidents and the number of victims for 2017-2018 were constructed. It was found that the greatest number of injured (wounded or dead) is observed in collisions and hitting a pedestrian. Then, road sections of the concentration of accidents were analyzed, the most common types of accidents and the main violations of traffic rules that contribute to the occurrence of accidents were determined. To identify hidden relationships between factors and accidents with severe consequences, association rules were applied. As a result, the influence of weather conditions, quality of road infrastructure and marking was established.

Paper #1

A Study of the Travel Time of Intersections by Vehicles using Computer Vision

V. Shepelev[1,2], A. Glushkov[1], Z. Almetova[1] and V. Mavrin[3]
[1] *South Ural State University, 76 Lenin Avenue, Chelyabinsk, Russia*
[2] *Silkway International University, 27 "A" Tokaev Street, Shymkent, Kazakhstan*
[3] *Kazan Federal University, Suyumbike Avenue, 10A, Naberezhnue Chelny, Russia*

Keywords: Vehicle Queue, Crossing the Intersections, Travel Time at Intersections, Statistical Confidence, Intelligent Transport Systems.

Abstract: The article deals with the problem of intelligent traffic control at intersections of road networks of large cities. Due to the advances in cyber-physical systems (CPS), autonomous driving, as part of Intelligent Transport Systems (ITS), will obviously be in the centre of future urban transport. However, the existing ITSs do not fully take into account the size, structure, and parameters of the queue of vehicles waiting at inter-sections, which in turn affects the traffic capacity of the intersection. In the study, we used computer vision to interpret a queue of vehicles and record the parameters at the intersection on a real time basis. We studied the mutual impact of two generalized categories of transport standing in the queue before the stop line at the intersection. We developed a general conceptual research model, which includes both the task of forming the original sample and statistical analysis of the time needed to cross an intersection by the vehicles located in different initial positions. The main research results showed a statistically significant reduction in the vehicle speed to 58% in case there are various categories of vehicles standing in the queue at the intersection.

Paper #5

Changing the Maintenance and Repair System While Expanding the Connected Vehicles Fleet

Irina Makarova[1], Vladimir Shepelev[2,3], Eduard Mukhametdinov[1] and Anton Pashkevich[4]

[1] *Kazan Federal University, Syuyumbike prosp., 10a, 423822, Naberezhnye Chelny, Russian Federation*

[2] *Silkway International University, Tokaev Street 27 "A"(housing A) Turkestan Street Corner, 160019, Shymkent City, Kazakhstan*

[3] *South Ural State University, ave. V.I. Lenin 76, 454080, Chelyabinsk, Russian Federation*

[4] *Politechnika Krakowska, Warszawska st., 24, Krakow, Poland*

Keywords: Connected Vehicles, On-board Diagnostic Systems, Branded Service Systems.

Abstract: Autonomous vehicles have become a logical outcome of the realization to Intelligent Transport Systems direction as a system strategy. The article analyses the directions of road vehicles intellectualization. The problems and ways to improve the safety, reliability and sustainability of transport systems are indicated. It is shown that to control the connected vehicles reliability it is necessary to improve the branded systems of maintenance and repair. This is realized through the improvement of on-board diagnostic systems. The use of sensors that read data on the vehicle's state, its routes and external factors affecting reliability ensure the adequacy and quality of the source information. Using a single information space for generating operational databases as well as a defect codifier for generating failure statistics and their multidimensional analysis will allow us to determine the service strategy and also carry out its adjustment if necessary when changing the failure statistics.

Time Break **VEHITS**
16:45 - 17:00 **Room Time Break**

Session 6A **VEHITS**
17:00 - 18:45 **Room 4**
Vision and Image Processing

Paper #14

3D Object Detection from LiDAR Data using Distance Dependent Feature Extraction

Guus Engels[1], Nerea Aranjuelo[1], Ignacio Arganda-Carreras[2,3,4], Marcos Nieto[1] and Oihana Otaegui[1]

[1] *Vicomtech Foundation, Basque Research and Technology Alliance (BRTA), Mikeletegi 57, San Sebastian, Spain*

[2] *Basque Country University (UPV/EHU), San Sebastian, Spain*

[3] *Ikerbasque, Basque Foundation for Science, Bilbao, Spain*

[4] *Donostia International Physics Center (DIPC), San Sebastian, Spain*

Keywords: LiDAR, 3D Object Detection, Feature Extraction, Point Cloud.

Abstract: This paper presents a new approach to 3D object detection that leverages the properties of the data obtained by a LiDAR sensor. State-of-the-art detectors use neural network architectures based on assumptions valid for camera images. However, point clouds obtained from LiDAR data are fundamentally different. Most detectors use shared filter kernels to extract features which do not take into account the range dependent nature of the point cloud features. To show this, different detectors are trained on two splits of the KITTI dataset: close range (points up to 25 meters from LiDAR) and long-range. Top view images are generated from point clouds as input for the networks. Combined results outperform the baseline network trained on the full dataset with a single backbone. Additional research compares the effect of using different input features when converting the point cloud to image. The results indicate that the network focuses on the shape and structure of the objects, rather than exact values of the input. This work proposes an improvement for 3D object detectors by taking into account the properties of LiDAR point clouds over distance. Results show that training separate networks for close-range and long-range objects boosts performance for all KITTI benchmark difficulties.

Paper #87

Practical Depth Estimation with Image Segmentation and Serial U-Nets

Kyle Cantrell, Craig Miller and Carlos Morato

Department of Robotics Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA, U.S.A.

Keywords: Autonomous Vehicles, Depth Estimation, Ensemble Neural Networks, Intelligent Transport Systems, Semantic Segmentation, U-Net, Vehicle Perception, VSLAM.

Abstract: Knowledge of environmental depth is required for successful autonomous vehicle navigation and VSLAM. Current autonomous vehicles utilize range-finding solutions such as LIDAR, RADAR, and SONAR that suffer drawbacks in both cost and accuracy. Vision-based systems offer the promise of cost-effective, accurate, and passive depth estimation to compete with existing sensor technologies. Existing research has shown that it is possible to estimate depth from 2D monocular vision cameras using convolutional neural networks. Recent advances suggest that depth estimate accuracy can be improved when networks used for supplementary tasks such as semantic segmentation are incorporated into the network architecture. A novel Serial U-Net (NU-Net) architecture is introduced as a modular, ensembling technique for combining the learned features from N-many U-Nets into a single pixel-by-pixel output. Serial U-Nets are proposed to combine the benefits of semantic segmentation and transfer learning for improved depth estimation accuracy. The performance of Serial U-Net architectures are characterized by evaluation on the NYU Depth V2 benchmark dataset and by measuring depth inference times. Autonomous vehicle navigation can substantially benefit by leveraging the latest in depth estimation and deep learning.

Paper #47

Multiple Path Prediction for Traffic Scenes using LSTMs and Mixture Density Models

Jaime Fernandez, Suzanne Little and Noel O'connor

Insight Centre for Data Analytics, Dublin City University, Dublin, Ireland

Keywords: Multiple Path Prediction, Traffic Scenes, LSTMs, MDNs, Time Series.

Abstract: This work presents an analysis of predicting multiple future paths of moving objects in traffic scenes by leveraging Long Short-Term Memory architectures (LSTMs) and Mixture Density Networks (MDNs) in a single-shot manner. Path prediction allows estimating the future positions of objects. This is useful in important applications such as security monitoring systems, Autonomous Driver Assistance Systems and assistive technolo-

gies. Normal approaches use observed positions (tracklets) of objects in video frames to predict their future paths as a sequence of position values. This can be treated as a time series. LSTMs have achieved good performance when dealing with time series. However, LSTMs have the limitation of only predicting a single path per tracklet. Path prediction is not a deterministic task and requires predicting with a level of uncertainty. Predicting multiple paths instead of a single one is therefore a more realistic manner of approaching this task. In this work, predicting a set of future paths with associated uncertainty was archived by combining LSTMs and MDNs. The evaluation was made on the KITTI and the CityFlow datasets on three type of objects, four prediction horizons and two different points of view (image coordinates and birds-eye view).

Paper #65

Integrating Multiscale Deformable Part Models and Convolutional Networks for Pedestrian Detection

Wen-Hui Chen, Chi-Wei Kuan and Chuan-Cho Chiang

Graduate Institute of Automation Technology, National Taipei University of Technology, Taipei, Taiwan

Keywords: Advanced Driver Assistance Systems, Convolutional Neural Networks, Deformable Part Models, Pedestrian Detection.

Abstract: Pedestrian detection has many real-world applications, such as advanced driver assistance systems, security surveillance, and traffic control, etc. One of the pedestrian detection challenges is the presence of occlusion. In this study, a jointly learned approach using multiscale deformable part models (DPM) and convolutional neural networks (CNN) is presented to improve the detection accuracy of partially occluded pedestrians. Deep convolutional networks provide a framework that allows hierarchical feature extraction. The DPM is used to characterize non-rigid objects on the histogram of oriented gradients (HoG) feature maps. Scores of the root and parts filters derived from the DPM are used as deformable information to help improve the detection performance. Experimental results show that the proposed jointly learned model can effectively reduce the miss rate of CNN-based object detection models tested on the Caltech pedestrian dataset.

Special Session - Session 2 **iMLTrans**
17:00 - 18:45 **Room 5**
Intelligent Mobility, Logistics and Transport

Paper #6

Improving the Road Network of Small Cities

Vadim Mavrin[1], Kirill Magdin[1], Aleksandr Barinov[2], Aleksey Boyko[1] and Artur Cherpakov[1]

[1] *Kazan Federal University, Suyumbike Avenue, 10A, Naberezhnye Chelny, Russian Federation*

[2] *Murmansk State Technical University, str. Sportivnaya, 13, Murmansk, Russian Federation*

Keywords: Transport System, Traffic Light Regulation, Intelligent Transport Systems, Simulation Modelling.

Abstract: The transport system is an important part in human activity and is an integral part of the successful functioning of an urbanized territory. The historical relationship between the size of the city and the development of urban transport is traced very well. With the growth of the city's population and its territory, there is an increase in vehicles and traffic volume. The mobility of the population is increasing (the average number of transport trips per resident per year), while the travel distance is also increasing. This requires the appropriate development of transport, increasing traffic speed, and increasing the capacity of the road network. The article is devoted to environmental problems of motor transport in small cities, where it is impossible to apply large and expensive solutions. Two problematic intersections in similar cities were considered in Apatity and Elabuga and measures for the reconstruction of these sections were proposed (applying adequate road markings and changing traffic lights modes). Performing a computer experiment on constructed simulation models showed that there is a significant potential for improving the parameters of traffic flow in these areas and reducing the negative impact on the environment.

Paper #7

Connected Vehicles Fleet Expanding Problems

Larisa Gabsalikhova[1], Irina Makarova[1], Vladimir Shepelev[2,3], Larisa Fatikhova[1] and Eduard Belyaev[1]

[1] *Kazan Federal University, Syuyumbike prosp., 10a, 423822, Naberezhnye Chelny, Russian Federation*

[2] *Silkway International University, Tokaev street 27 "A"(housing A) Turkestan Street Corner, 160019, Shymkent city, Kazakhstan*

[3] *South Ural State University, ave. V.I. Lenin 76, 454080, Chelyabinsk, Russian Federation*

Keywords: Connected Vehicles, Fleet Expanding, Problems.

Abstract: The transport systems intellectualization directions analysed in article. The digital technology introduction occurs at all stages of the vehicle life cycle: product development, preparation and production launch, product manufacture, its operation and maintenance. The autonomous vehicles fleet expanding problems are indicated. The intelligent vehicles development and the varying degrees of intellectualization vehicles fleet expansion is accompanied by a number of problems, including those related to the influence of social factors on the transition to fully autonomous vehicles. Consumers are still worried about the consequences of introducing such vehicles, which is related to the security problems. The risk assessment of connected vehicles introduction to the market has been performed. The article concludes with an analysis of connected vehicles ensuring the reliability technical problems.

Paper #8

Dynamic Prices in Retail and Its Impacts on Logistics

Onur Guvenc[1], Aiman Kazybayeva[1] and Kuanysh Abeshev[2]

[1] *School of Management, Almaty Management University, 227 Rozibakiyeva, Almaty, Kazakhstan*

[2] *School of Engineering Management, Almaty Management University, 227 Rozibakiyeva, Almaty, Kazakhstan*

Keywords: Gamification, Retail, Inventory, Logistics, Dynamic Price.

Abstract: Various factors have contributed to the immense growth of dynamic pricing: demand data, technology, and decision support tools. A sample survey was conducted to get the perspectives of small business owners in retail and consumers to understand their perspective on dynamic consumer pricing and its effects on logistics. The survey questions were structured in a way to provide perspectives on consumer experience and buying behaviour

concerning dynamic pricing and gamification. The study realized retail companies are not well prepared for the logistical changes due to dynamic pricing. Traditionally, retail stores have focused on ensuring that the supply chain is responsive to client demands. For instance, leftover inventory was seen as a problem arising from poor decisions on dynamic pricing. After a promotional selling season, many of the retail respondents indicated that they face problems of when and how much to mark down leftover inventory.

Paper #9

Using Simulation to Evaluate Shuttle Service Efficiency

Kuanysh Abeshev[1], Polina Buyvol[2], Ksenia Shubenkova[2] and Timur Gabdullin[2]

[1] *School of Engineering Management, Almaty Management University, Rozybakiyeva st., 227, 050060, Almaty, Kazakhstan*

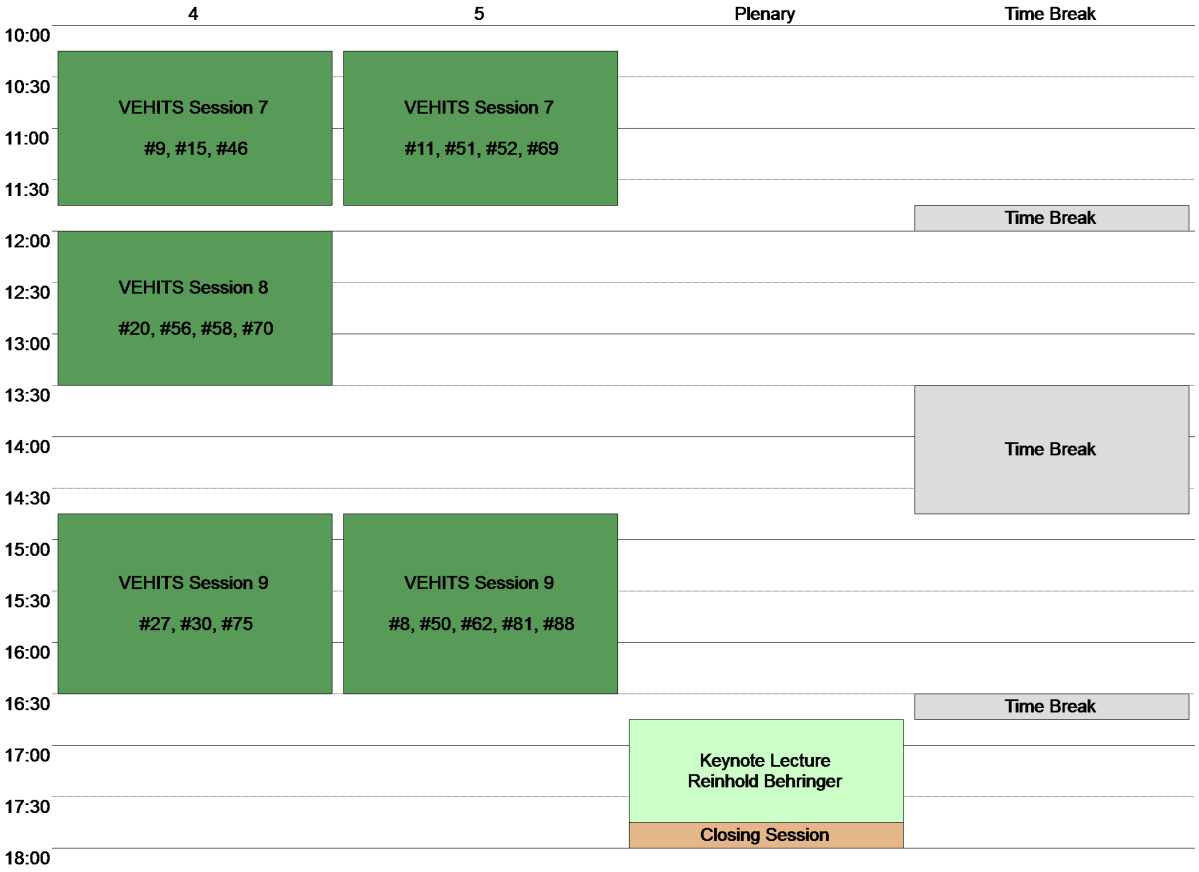
[2] *Kazan Federal University, Syuyumbike prosp., 10a, 423822 Naberezhnye Chelny, Russian Federation*

Keywords: e-Mobility, Shuttle Service, Simulation, Smart City, Transport System.

Abstract: The work is devoted to the study of the influence of the Smart City concept on the city transport system. It is shown that in cities where industrial zones are separated from residential ones, there are problems with increasing transport load in the morning and evening peak hours. Various methods (special routes, special tariffs, etc.) are used to solve the problem of delivering workers to places of work, but, in our opinion, these solutions should be combined with the concept of E-mobility, which implies both a transition to environmentally friendly types of transport, and an increase in the stability of the transport system by reducing the intensity of the traffic flow. This can be done through the organization of shuttle service of enterprises' employees, which will allow to refuse using of personal cars for trips to work. An example of the solution of the transport routing problem for the Naberezhnye Chelny city is given.

Monday Sessions: May 4

Monday Sessions: May 4 Program Layout



Session 7A **VEHITS**
10:15 - 11:45 **Room 4**
Vehicle Environment Perception

Paper #9

Aware and Intelligent Infrastructure for Action Intention Recognition of Cars and Bicycles

Cristofer Englund[1,2]

[1] *Center for Applied Intelligent Systems Research (CAISR), Halmstad University, SE 30118 Halmstad, Sweden*

[2] *RISE Research Institutes of Sweden, Mobility and Systems, Humanized Autonomy, Lindholmspiren 3A, SE 41756 Göteborg, Sweden*

Keywords: Intention Recognition, Random Forest, Data Mining, Traffic Behavior Modelling, Variable Selection, Aware Systems.

Abstract: Action intention recognition is becoming increasingly important in the road vehicle automation domain. Autonomous vehicles must be aware of their surroundings if we are to build safe and efficient transport systems. This paper explores methods for predicting the action intentions of road users based on an aware and intelligent 3D camera-based sensor system. The collected data contains trajectories of two different scenarios. The first one includes bicyclists and the second cars that are driving in a road approaching an intersection where they are either turning or continuing straight. The data acquisition system is used to collect trajectories of the road users that are used as input for models trained to predict the action intention of the road users.

Paper #46

Pedestrian Head and Body Pose Estimation with CNN in the Context of Automated Driving

Michaela Steinhoff[1] and Daniel Göhring[2]

[1] *Business Area Intelligent Driving Functions, IAV GmbH, Rockwellstr. 3, 38518 Gifhorn, Germany*

[2] *Institute of Computer Science, Freie Universität Berlin, Arnimallee 7, 14195 Berlin, Germany*

Keywords: Automated Driving, Convolutional Neural Network, Headpose, Pedestrian Intention, Semi-supervision.

Abstract: The challenge of determining pedestrians head poses in camera images is a topic that has already been researched extensively. With the ever-increasing level of automation in the field of Advanced Driver Assistance Systems, a robust head orientation detection is becoming more and more important for pedestrian safety. The fact that this topic is still relevant, however, indicates the complexity of this task. Recently, trained classifiers for discretized head poses have recorded the best results. But large databases, which are essential for an appropriate training of neural networks meeting the special requirements of automatic driving, can hardly be found. Therefore, this paper presents a framework with which reference measurements of head and upper body poses for the generation of training data can be carried out. This data is used to train a convolutional neural network for classifying head and upper body poses. The result is extended in a semi-supervised manner which optimizes and generalizes the detector, so that it is applicable to the prediction of pedestrian intention.

Paper #15

Real-time Spatial-temporal Context Approach for 3D Object Detection using LiDAR

K. Kumar[1] and Samir Al-Stouhi[2]

[1] *Great Wall of Motors, Whitefield, Bangalore, Karnataka, India*

[2] *American Haval Motors, Michigan, U.S.A.*

Keywords: Bird's-Eye-View (BEV), Convolutional Neural Network (CNN), Non-Local Context Network (NLCN), YOLO, Convolutional LSTM (CLSTM), Spatial-Temporal Context Network (STCN).

Abstract: This paper proposes a real-time spatial-temporal context approach for BEV object detection and classification using LiDAR point-clouds. Current state-of-art BEV object-detection approaches focused mainly on single-frame point-clouds while the temporal factor is rarely exploited. In current approach, we aggregate 3D LiDAR point clouds over time to produce a 4D tensor, which is then fed to a one-shot fully convolutional detector to predict oriented 3D object bounding-box information along with object class. Four different techniques are evaluated to incorporate the temporal dimension; a) joint training b) CLSTM c) non-local context network (NLCN) d) spatial-temporal context network (STCN). The experiments are conducted on large-scale Argoverse dataset and results shows that by using NLCN and STCN, mAP accuracy is increased by a large margin over single frame 3D object detector and YOLO4D 3D object detection with our approach running at a speed of 28fps.

Session 7B **VEHITS**
10:15 - 11:45 **Room 5**
Information Systems and Technologies

Paper #11

How Did You Like This Ride? An Analysis of User Preferences in Ridesharing Assignments

Sören Schleibaum[1], Maike Greve[2], Tim-Benjamin Lembcke[2], Amos Azaria[3], Jelena Fiosina[1], Noam Hazon[3], Lutz Kolbe[2], Sarit Kraus[4], Jörg Müller[1] and Mark Vollrath[5]

[1] *Department of Informatics, Clausthal University of Technology, Julius-Albert Straße 4, Clausthal-Zellerfeld, Germany*

[2] *Chair of Information Management, University of Göttingen, Platz der Göttinger Sieben 5, Göttingen, Germany*

[3] *Department of Computer Science, Ariel University, Israel*

[4] *Department of Computer Science, Bar-Ilan University, Israel*

[5] *Chair of Engineering and Traffic Psychology, TU Braunschweig, Germany*

Keywords: User Preferences, Ridesharing, Assignment, Shared Mobility, Platform Economy.

Abstract: Ridesharing can significantly reduce individual passenger transport and thus greenhouse gas emissions generated by traffic. Although ridesharing offers great potential, it is not yet popular enough to be seen as an important contribution to solving the aforementioned problems. Our hypothesis suggests that we need to make the assignment mechanism of ridesharing systems more human-centric and comprehensible in order to popularise ridesharing. Therefore, we investigate factors that influence the choice of users and their satisfaction with the assigned ride. Most of today's ridesharing assignment algorithms focus solely on features such as time, distance and price. Contrarily, this paper examines additional factors that influence customer decisions to increase their satisfaction. Therefore, we first conduct a literature

study to identify previous preferences relevant for ridesharing from a research perspective. Subsequently, we extract the relevant preferences for an assignment process. From these we secondly conduct a survey. Last, we analyse the obtained survey data and order the preferences based on their importance for participants overall and among demographic subgroups.

Paper #51

A Key Performance Optimization Agent-based Approach for Public Transport Regulation

Nabil Morri[1,2], Sameh Hadouaj[3,2] and Lamjed Ben Said[2]

[1] *IT Department, Emirates College of Technology, Abu Dhabi, U.A.E.*

[2] *SMART Lab., Institut Supérieur de Gestion de Tunis, Université de Tunis, Tunisia*

[3] *Computer Information Systems Department, Higher Colleges of Technology, U.A.E.*

Keywords: Intelligent Transportation System, Multi-agent System, Optimization, Control Support System, Simulation.

Abstract: Today's, an efficient and reliable public transport system becomes essential to assist cities in their wealth creation. However, public transportation systems are highly complex because of the modes involved, the multitude of origins and destinations, and the amount and variety of traffic. They have to cope with dynamic environments where many complex and random phenomena appear and disturb the traffic network. To ensure a good quality service, perturbations caused by these phenomena must be detected and treated within an acceptable time frame via the use of a control system. The control process should rely on many criteria related to the traffic management of public transport: Key Performance Indicators. In this paper, we introduce a Regulation Support System of Public Transport (RSSPT) that detects and regulates the traffic perturbation of multimodal public transportation. The system uses optimization techniques to solve the control problem. We based our regulation support system on a multi-agent approach to cope with the distributed nature of the public transportation system. To validate our model, we conducted tests by simulating perturbation scenarios in a real traffic network. A comparison between real data and the obtained results shows an improvement in the quality service.

Paper #52

Automatic Train Operation: History and Open Questions

Aleš Lieskovský[1], Ivo Myslivec[1] and Michal Žemlička[1,2,3]

[1] *Závod Technika, A ŽD Praha, s.r.o., Žirovnická 3146/2, Praha 10, Czech Republic*

[2] *Department of Informatics, Jan Evangelista Purkyně University, České mládeže 8, Ústí nad Labem, Czech Republic*

[3] *Department of Software and Computer Science Education, Charles University, Praha, Czech Republic*

Keywords: Automatic Train Operation, ATO Strategy, Human-machine Interface.

Abstract: The paper presents the concept of automatic train operation. We give here short description of its functionality and remember some points from its history. There is an overview of various future development as well as proposals for improvement of some existing, especially mainline, solutions. There are presented also some observations from decades of practical use of automatic train operation in the Czech Republic. Selected challenges are presented and discussed.

Paper #69

Taxi Demand Prediction based on LSTM with Residuals and Multi-head Attention

Chih-Jung Hsu and Hung-Hsuan Chen

Computer Science and Information Engineering, National Central University, Taoyuan, Taiwan

Keywords: LSTM, Multi-head Attention, Deep Learning, Residual Connection, Taxi Demand.

Abstract: This paper presents a simple yet effective framework to accurately predict the taxi demands of different regions in a city in the near future. This framework is based on a deep-learning structure with residual connections in the LSTM layers and the attention mechanism. We found that adding residuals accelerates optimization and that adding the attention mechanism makes the model better predict the taxi demands, especially when the demand fluctuates greatly in the peak hours and off-peak hours. We conducted extensive experiments by comparing the proposed models to the time-series model (ARIMA), traditional supervised learning model (ridge regression), strong machine learning model that won many Kaggle competitions (Gradient Boosted Decision Tree implemented in the XGBoost library), and deep learning models (LSTM and DMVST-Net) on two real and open-source datasets. Experimental results show that the proposed models outperform the baselines for most cases. We believe the greatest improvement comes from the attention mechanism, which helps distinguish the demands in the peak hours and off-peak hours. Additionally, the proposed model runs 10% to 40%-times faster than the other deep-learning-based models. We applied the models to participate in a taxi demand prediction challenge and won second place out of hundreds of teams.

Time Break	**VEHITS**
11:45 - 12:00	**Room Time Break**

Session 8A	**VEHITS**
12:00 - 13:30	**Room 4**
Big Data Analytics for Intelligent Transportation	

Paper #20

Machine Learning based Video Processing for Real-time Near-Miss Detection

Xiaohui Huang, Tania Banerjee, Ke Chen, Naga Varanasi, Anand Rangarajan and Sanjay Ranka

Modern Artificial Intelligence and Learning Technologies (MALT) Lab, University of Florida, U.S.A.

Keywords: Near-Miss Detection, Fisheye Camera, Intersection Video, Calibration, Thin-plate Spline, Deep Learning.

Abstract: Video-based sensors are ubiquitous and are therefore indispensable in understanding traffic behavior at intersections. Deriving near-misses from large scale video processing is extremely useful in assessing the level of safety of intersections. In this paper, we develop real-time or near real-time algorithms for detecting near-misses for intersection video collected using fisheye cameras. We propose a novel method consisting of the following steps: 1) extracting objects and multiple object tracking features using convolutional neural networks; 2) densely mapping object coordinates to an overhead map; 3) learning to detect near-misses by new distance measures and temporal motion. The experimental results demonstrate the effectiveness of our approach with real-time performance at 40 fps and high specificity.

Paper #56

A Visual Analytics System for Processed Videos from Traffic Intersections

Ke Chen, Tania Banerjee, Xiaohui Huang, Anand Rangarajan and Sanjay Ranka
CISE, University of Florida, Gainesville, Florida, U.S.A.

Keywords: Visual Analytics, Intersection Traffic Analysis, Trajectory Analysis, Anomaly Detection.

Abstract: Traffic intersections are the most crucial areas that determine the efficiency of a road network. With the advances in technology, it is now possible to gather real-time data on the performance of an intersection and identify potential inefficiencies. The goal of our work is to develop a visual analytics framework based on videos collected at an intersection using fisheye cameras. The software developed as part of this work is described in detail, along with its utility and usability. The software may be used to filter and display tracks and sort them based on the most frequent signaling phases encountered at an intersection. The software may be used to study anomalous trajectories, such as those that have unusual shapes and those that occur at times that violate the ongoing signal phase. While being useful for analyzing the trajectories at an intersection, the software is also convenient for developers seeking to validate algorithms for the trajectory generation process, object classification, preprocessing, and clustering trajectories.

Paper #58

Data Mining Algorithms for Traffic Interruption Detection

Yashaswi Karnati, Dhruv Mahajan, Anand Rangarajan and Sanjay Ranka
Department of Computer and Information Science and Engineering, University of Florida, Gainesville, FL, U.S.A.

Keywords: Incident Detection, Loop Detectors Systems, Traffic Interruptions, Semi-Supervised, Data Mining.

Abstract: Detection of traffic interruptions (caused by vehicular breakdowns, road accidents etc.) is a critical aspect of managing traffic on urban road networks. This work outlines a semi-supervised strategy to automatically detect traffic interruptions occurring on arteries in urban road networks using high resolution data from widely deployed fixed point sensors (inductive loop detectors). The techniques highlighted in this paper are tested on data collected from detectors installed on more than 300 signalized intersections.

Paper #70

Exploring Spatio-temporal Movements for Intelligent Mobility Services

Tobias Grüner[1], Sören Frey[1], Jens Nahm[1] and Dirk Reichardt[2]
[1] *Independent Researcher, 70563 Stuttgart, Germany*
[2] *Baden-Wuerttemberg Cooperative State University Stuttgart (DHBW Stuttgart), Jägerstraße 56, 70174 Stuttgart, Germany*

Keywords: Mobility Services, Machine Learning, Prediction, Classification, POI Extraction, Clustering, Location Data.

Abstract: Mobility services can substantially benefit from incorporating movement behavior information. Models of daily travel routines can facilitate intelligent recommendations of suitable car sharing, ride pooling, or Mobility as a Service (MaaS) offerings, for instance. However, existing approaches that infer regular travel activities from historical location data exhibit several limitations. For example, they often have an insufficient resolution in the spatial and temporal dimension or are restricted to predicting only the next location visit. This paper presents an activity-based approach to model daily travel routines and predict regularities with the help of machine learning (ML). We first extract points of interest (POIs) and corresponding visits from historical location data. Then, regularities for these visits are identified with the help of classification. We validate our work in progress approach using data from voluntary, consenting test subjects (CTS) who agreed to track their movements. They labeled their own data for each activity with corresponding regularity information. We show that POI visits can already be predicted reliably for the first classes of movements.

Time Break **VEHITS**
13:30 - 14:45 **Room Time Break**

Session 9A **VEHITS**
14:45 - 16:30 **Room 5**
Intelligent Vehicle Technologies

Paper #62

Linked Real and Virtual Test Environment for Distributed C-ITS-Applications

Michael Klöppel-Gersdorf and Thomas Otto
Fraunhofer IVI, Fraunhofer Institute for Transportation and Infrastructure Systems, Dresden, Germany

Keywords: V2X, Simulation, Hardware-in-the-Loop, Testing.

Abstract: The development and test of automated and connected driving, based on vehicle-to-infrastructure (V2I) communication, is essential for C-ITS pilot implementations. Even today, the deployment and test of these services is a great challenge. Multiple connections, interfaces as well as interactions between several entities make it difficult to find and eliminate malfunction of cooperative components. The ranges and boundaries of drive and test scenarios make debugging during test drives in a real traffic environment substantially difficult, because it requires reproducible conditions. The solution of the above mentioned problem is a linked real and virtual test environment for distributed C-ITS-Applications under test. A microscopic simulation of traffic scenarios running on a test environment computer is combined with a real signal control device including traffic lights, real roadside unit and a real on-board unit for the communication between infrastructure (traffic lights) and vehicle (on-board unit). This hardware and software-in-the-loop (HiL/SiL)

approach enables the use of reproducible drive and test scenarios for testing C-ITS-Applications based on an interaction of different traffic conditions, traffic light devices and vehicles.

Paper #81

Petri Net-based Smart Parking Information System

Omar Makke and Oleg Gusikhin
Global Data Insight And Analytics, Ford Motor Company, 22001 Michigan Ave, Dearborn, Michigan, U.S.A.

Keywords: Smart Parking, IoT, Petri Nets, Mobility, Smart City, Digital Twin.

Abstract: In this paper, we propose a Petri Net digital twin solution for smart parking information system to track the occupancy of a parking space while respecting the privacy of the drivers. An edge computing device is deployed to process camera images, and a Petri Net model is generated from the event logs and tracks the occupancy of the parking structure. This type of solution can be enhanced to any desirable level of accuracy. The paper provides preliminary analytics for the parking dynamics in a period of three months. This analysis clearly demonstrates the tangible benefits of the parking information system.

Paper #8

Online Driving Behavior Scoring using Wheel Speeds

Marian Waltereit, Peter Zdankin, Viktor Matkovic, Maximilian Uphoff and Torben Weis
Distributed Systems Group, University of Duisburg-Essen, 47048 Duisburg, Germany

Keywords: Driving Behavior, Aggressive Driving, Driver Feedback, Wheel Speeds, Controller Area Network.

Abstract: We present an online scoring algorithm for measuring driving behavior using wheel speeds only. Such an algorithm can be used to provide drivers with feedback about their driving behavior while driving in order to reduce aggressive driving, which is a primary cause of traffic accidents. Our algorithm uses a minimal data set already available through the built-in wheel speed sensors of contemporary cars. Due to the small amount of data used and the low computational complexity, our algorithm can easily be deployed on single-board computers. With real driving experiments in a controlled and an uncontrolled environment, we demonstrate the suitability of our scoring algorithm for identifying aggressive driving and assessing the driving behavior.

Paper #50

An Automatic Scenario Generator for Validation of Automated Valet Parking Systems

Andrea Tagliavini[1], Donato Ferraro[1], Tomasz Kloda[2] and Paolo Burgio[1]
[1] *Università degli studi di Modena e Reggio Emilia, Italy*
[2] *Technical University of Munich, Germany*

Keywords: Simulators, Autonomous Driving, Scenario Generation, Valet Parking, Virtual Test Drive, OpenSCENARIO.

Abstract: A primary goal of self-driving car manufacturers is to create an autonomous car system that is clearly and demonstrably safer than an average human-controlled car. The real-world tests are expensive, time-consuming and potentially dangerous. The virtual simulation is therefore required. The autonomous driving valet parking is expected to be the first commercially available automated driving function without a human driver at the wheel (SAE Level 4). Although many simulation solutions for the automotive market already exist, none of them features the parking environments. In this paper, we propose a new software virtual scenario generator for the parking sites. The tool populates the synthetics parking maps with objects and actions related to these environments: the cars driving from the drop-off point towards the vacant slots and the randomly placed parked cars, each with a given probability of exiting its slot. The generated scenarios are in the OpenSCENARIO format and are fully simulated in the Virtual Test Drive simulator.

Paper #88

Efficient and Selective Upload of Data from Connected Vehicles

Zaryab Khan[1,2] and Christian Prehofer[1]
[1] *DENSO Automotive Germany, Germany*
[2] *Technical University of Munich, Germany*

Keywords: Connected Vehicles, Data Collection, Connected Mobility.

Abstract: Vehicles are evolving into a connected sensing platform, generating enormous amounts data about themselves and their surroundings. In this work, we focus on the efficient data collection for connected vehicles, exploiting the fact that the context data of cars on the same road is often redundant. This is for instance relevant for applications which need roadside data for map updating. We propose a vehicular data dissemination architecture with a central coordination scheme to avoid redundant uploads. It also uses roadside WiFi hotspots opportunistically. To evaluate the benefits, we use the SUMO simulator to benchmark our results against a baseline solution, showing improvements of factor 10 up to 20.

Session 9B **VEHITS**
14:45 - 16:30 **Room 4**
Road Safety and Transport Security

Paper #27

The Comparison of 3D and 2D Measurement Techniques Used for the Analysis of Vehicle Deformation

Pavlína Moravcová[1,2], Kateřina Bucsuházy[2,1], Robert Zůvala[2], Martin Bilík[1] and Albert Bradáč[1]
[1] *Institute of Forensic Engineering, Brno University of Technology, Czech Republic*
[2] *Transport Research Centre, Brno, Czech Republic*

Keywords: Vehicle, Deformation, 2D, 3D, Accident Analysis, Laser Scan.

Abstract: As one of the main assumptions for the accident analysis has been detailed information about vehicle deformation. The precise deformation depth allows to quantify deformation energy and related impact speed. The aim of this paper has been the comparison of two selected methods used for the determination of deformation depth. For the purpose of this paper

were selected top-view photography as basic and cheap method and 3D scanning as modern and advanced method. Different vehicles and 2 basic types of damage - frontal and side impact - were chosen for the analysis. Also, the different range of vehicle deformation depth were selected. On the basis of obtained results is possible to determine the applicability of these methods, their advantages and limitations.

Paper #30

Evaluating the Dedicated Short-range Communication for Connected Vehicles against Network Security Attacks

Tu Le, Ingy Elsayed-Aly, Weizhao Jin, Seunghan Ryu, Guy Verrier, Tamjid Al Rahat, B. Park and Yuan Tian

School of Engineering and Applied Science, University of Virginia, Charlottesville, Virginia, U.S.A.

Keywords: Cybersecurity, Network, DSRC, Connected Vehicles, VANET.

Abstract: According to the National Highway Traffic Safety Administration, there are more than 5 million road crashes every year in the U.S. More than 90 people die in car crashes every day. Even though the number of people surviving crashes has increased significantly thanks to safety features, such as airbags and anti-lock brakes, many people experience permanent injuries. The U.S. Department of Transportation introduced connected vehicle technologies, which enables vehicles to “talk” to each other and exchange important data on the roads, with the goal of preventing crashes from happening in the first place. With the rapid development of autonomous driving technology, vehicles in the near future will be able to operate completely without human drivers, increasing the need of reliable connected vehicle technologies. Due to the safety-critical characteristics of autonomous vehicles, it is important to evaluate the technologies extensively prior to deployment to ensure the safety of drivers, passengers, and pedestrians. In this paper, we evaluate the safety of Dedicated Short-Range Communication (DSRC), which is a popular low-latency wireless communication technology specifically designed for connected vehicles. We present three real-world network security attacks and conduct experiments on real DSRC-supported modules. Our results show that DSRC is vulnerable to these dangerous attacks and such attacks can be easily implemented by adversaries without significant resources. Based on our evaluation, we also discuss potential countermeasures to better improve the security and safety of DSRC and connected vehicles.

Paper #75

Constructing Tool-based Security Test Sequences for Vehicles as High-tech Data-rich Systems

Alexandr Vasenev[1], Stelios Karagiannis[2] and Roland Mathijssen[1]

[1] *Joint Innovation Centre ESI (TNO), Eindhoven, The Netherlands*

[2] *Beyond Vision, Ilhavo, Portugal*

Keywords: Test Sequences, Method, Reference Architecture, Pen Testing, Open Source.

Abstract: Vehicles, as a prime example of high-tech systems, get increasingly connected and data-centric with the need to process personally identifiable information. Often, companies that develop such systems act as integrators and need to comply to adequate data protection requirements. For instance, GDPR requires securing personal data. Yet, testing security of data (including, but not limited to personal data) is challenging. Penetration testing often starts from the outside of the system and take place at the end of the development lifecycle. This may be insufficient to adequately test for potential errors hidden within system boundaries. Having methods to design, execute, and reuse (automated) security test cases on a ‘white-box’ system is desirable. This positioning paper proposes an approach to design tool-based security test sequences. We structurally approach high-level data storing, processing, and communicating functionality in connection to the system boundary. We suggest to use pen-testing tools and sequences for testing the functionality of the vehicle’s (sub)system, before test-enabling interfaces are removed. This paper intends to contribute to discussions how to test layered defense implementations. The proposed approach is undergoing extensions and validations.

Time Break	**VEHITS**
16:30 - 16:45	**Room Time Break**

Keynote Lecture	**VEHITS**
16:45 - 17:45	**Room Plenary**

Autonomously Driving Trucks - Challenges and Opportunities

Reinhold Behringer

Knorr Bremse GmbH, Kirchentellinsfurt, Germany

Abstract: The development of autonomously driving trucks could be the first business case where autonomous driving technology is used purposefully in a commercial environment. In recent years, trucks in Europe are already required to have specific driver assistance technologies installed, for safer driving on motorways avoiding collisions. Trucks have a lot of kinetic energy because of the potentially large mass (e.g. 40 tons). Therefore, safety of truck driving does have a high priority, because accidents are often fatal. All truck manufacturers and also suppliers are working towards higher degrees of autonomy of truck driving, with the goal of reducing the number of accidents. Specific challenges are the different constraints regarding sensor mounting. Most truck cabins have their own motion characteristics due to specific suspension technologies, which need to be taken into account when mounting sensors. Also the maneuverability of a truck is different than that of a passenger vehicle. This talk will present the challenges in the development of fully autonomous trucks and will focus on specific recent developments which will lead to a revolution of the road freight transport systems.

Closing Session	**VEHITS**
17:45 - 18:00	**Room Plenary**

Author Index

Final Program and Book of Abstracts of VEHITS 2020

6th International Conference on Vehicle Technology and Intelligent Transport Systems

http://www.vehits.org