

2nd Special Session on Solving the Automated Vehicle Safety Assurance Challenge

Maria Soledad Elli¹, Ignacio Alvarez¹, Jeffrey Ota¹, Jack Weast¹ and Markus Maurer²

Abstract—The scientific knowledge and tools for the mass deployment of Automated Vehicles (AVs) are maturing rapidly, as evidenced by the wide deployment of AV test fleets worldwide. These vehicles have the potential to produce tremendous economic and societal benefits including greatly reduced traffic accidents, injuries, and congestion, and to make less expensive, more flexible and more productive transportation available to all. But one challenge looms above all others in the race to full vehicle automation; solving the AV Safety Assurance challenge. Automated transportation is not just a product, but an industry. And it is as an industry that we must together solve this challenge. We invite researchers, automakers, technology companies, and government regulators to come together to develop a holistic model to define and measure AV Safety. In this special session we present papers that provide contributions to the definition, applicability and standardization of AV safety assurance, including methods for the development of metrics, benchmarks and evangelisation of AV Safety Assurances to users and the public. This session continues the open discussion started in 2018 ITSC with the goal of making AV Safety a reality. The session will consist of high quality paper presentations as well as a panel discussion with some of the most relevant figures of the AV industry.

I. AIM AND SCOPE

As automated vehicles make progress in their development, we think that in order to introduce such a disruptive technology into society it is imperative that we agree and understand the intrinsic properties that come with it. Defining safety, from the point of view of whether the AV is making safe logical decisions or not, and crafting regulations that can support the deployment of safe AV's are topics that will enable the mass production and world acceptance of automated vehicles. The aim of this session is to continue the discussion started at the first Special Session on Solving the Automated Vehicle Safety Assurance Challenge at IEEE ITSC 2018 where a diverse group of leaders from throughout the automated vehicle ecosystem came together for academic presentations, industry insights and an open panel discussion about the safety of automated vehicles.

The main goal of this special session is closing the gap towards finding a solution that is accepted throughout the industry, with regulators and the general public so that everyone can support a common, socially agreed definition of what it means for an AV to drive safely. As indicated by last year's discussion, the lack of the right metrics to address safety definitions as well as the definition of standardized acceptable levels of residual risk are still questions with no

concrete answers. Many researchers have started exploring the usage of the right tools (simulation, controlled tests in closed loops, etc) for real world deployment and evaluating new infrastructure for connected AVs as a way to avoid fatalities. The methods needed for reaching evidence of safety are going to be shaped by focused efforts like the one being proposed.

This session will promote and facilitate the collaboration between academics, industry experts and policy makers in order to specify the AV safety standards and tools that will help save millions of lives. By expanding our invitation to contributors to the AV Safety field from different parts of the world, including USA, Europe, Asia and Australasia, we seek to provide a universal view of how safety of driving is perceived differently around the world and how we can satisfy the regional differences across many cultures while still providing a high degree of safety assurance. This understanding is crucial for developing a general safety standard that can be applied worldwide.

A key result of this special session will be a deeper understanding and a stronger collaboration as a community in order to ensure, with the right tools, the safety of driving with an open and transparent approach.

II. TOPICS OF INTEREST

This special session welcomes topics focused on automated driving safety, including (but not limited to):

- 1 Definition and assurance of Safety for AV decision making
- 2 Standardization of AV safety – Formal and applied AV safety metrics
- 3 Methods and applicability of AV safety standards in real the world and methods for test, verification and validation of AV safety
- 4 Methods requirements definition of safe AVs
- 5 AV safety guarantees and transitions between simulation, test tracks and real world
- 6 Education and transparency to passengers and road user about AV Operational Domain Design and safety
- 7 Infrastructure requirements and deployments needed to ensure AV safety
- 8 AV safety in the era of Machine Learning
- 9 Coverage of AV safety and evidence of safety on AV
- 10 Trade-offs between naturalistic driving vs safe AV driving. How safe is safe enough?

¹Intel Corporation, ²Technical University Braunschweig

III. HISTORY OF THE SPECIAL SESSION

The first instance of this special session took place during the IEEE Intelligent Transportation Systems Conference 2018, in Maui, Hawaii, United States. This session brought together a diverse group of leaders from the automated driving environment to have an open conversation about safety of automated driving vehicles from research, industry and policy perspectives. The session provided 15 minutes plenary talks from leaders in industry, government and academia followed by a panel and group discussion with the audience moderated by Jeffrey Ota, from Intel Labs at Intel Corporation. The talks involved the participation of the following contributors:

Perspectives from the industry:

- Laura Fraade-Balnar, from RAND Corporation, provided an overview of the framework for Autonomous Driving Safety commissioned by Uber in 2017 where safety is defined as eliminating, minimizing, or managing of harm to the public (including people, animals, and property). In their report [1], safety is addressed along the stages of development, demonstration and deployment with testing environments such as simulation, closed course and public roads. As a learning, she highlighted lagging and leading measures of safety and that for the most part the public road reported metrics cannot be used to evaluate objectively AV safety.
- Sagar Bahere, from Toyota Research Institute, presented a holistic vision of safety highlighting that the current definition of safety focuses on goals but crucially does not clarify the context to achieve or measure those safety goals. He highlighted methods used at TRI to reach evidence of safety and the understanding that coverage of safety is always imperfect and need to understand the residual risk left from lack of testing or unknown context in real world deployments.
- Michael Wagner, from Edge Case Research, gave an overview of software safety for automated vehicles, including machine learning / AI based solutions through a layered approach with checks on ASIL certified models, AI development tools, Operational Domains and definition of standardized acceptable levels of residual risk.
- Jack Weast, from Intel Corporation, presented an overview to the Responsibility Sensitive Safety (RSS) [2], a formal framework to achieve safe vehicle automation retaining usefulness for customers.

Research Perspectives:

- Prof. Fei-yue Wang, from the Chinese Academy of Sciences, presented safety oriented parallel driving. A framework based on Parallel Driving Systems [3]

which specifies 3 levels of necessary safety (physical, SW-defined and artificial intelligence). He proposed vehicle safety needs to perform prescriptive, descriptive and prospective actions.

- Prof. Christoph Stiller, from Karlsruhe Institute of Technology, presented work for AV planning under uncompliant behaviors making the point that vehicles must infer position and behavior of potential vehicles under partially occluded or unknown areas such as intersections. His work highlighted that guaranteed safety of the ego vehicle must work even when other vehicles did not respect social rules, such as right of way.
- Prof. Huei Peng, from University of Michigan's MCity, introduced a safety approach which involves the use of the right mix of simulation, controlled test on closed-loops and real world deployment. The metrics gathered at MCity incorporate a behavior competence test with 35 usecases as an initial benchmark.

Perspectives on policies:

- Jeff Paniati, from the Institute of Transportation Engineers in US, highlighted a Government point of view of Automated Vehicle safety that relies heavily on infrastructure highlighting that in order to achieve zero fatalities we need Connected AVs.

The talks and panel discussion extended over 4 hours where many interesting discussions arose between panelists and the public, including limitations to the presented safety approaches veered towards guarantees of safety. There was also a general acceptance that the lack of safety definitions is hindering the selection of values in any safety formula that might be applied to AVs. This drove the discussion towards the more practical need to define what constitutes hazards and safety modes of operation and that these need to be transparent to passengers as well as other road users for a better world wide acceptance of AVs.

As a result of this special session, Intel Corporation has engaged on further research activities with Edge Case Research for software safety validation. Intel has also continued research engagements with Prof. Wang as part of the Intel Collaborative Research Institute (ICRI) on Intelligent Automated and Connected Vehicles that recently resulted in the publication of situation-awareness enhancement to safety for collision avoidance [4]. In addition, Intel invited the RAND Corporation to participate in a panel at CES on AV Safety to share the work they introduced first at the ITSC18 Special Session. Furthermore, Prof. Stiller's work created the seed for a newly formed research center on Automated Vehicle safety in Europe in which Intel's committed to support researchers to contribute to the industry.

IV. PROSPECTIVE AUTHORS AND CONTRIBUTIONS

We expect to receive between 8 and 12 high-quality submissions for consideration within the scope of Intel Automated Driving Safety academic research engagements in US, Europe, Asia and Australia. Following is a list of prospective contributors and topic of the contributions:

- Prof. Christoph Stiller contributions on extracting safety metrics from naturalistic driving datasets
- Contributions from the Institute of Automated Mobility in Arizona [5], on legal liability analysis of automated vehicle accidents and temporal analysis of RSS
- Contributions from University collaborators from our ICRI in China on Development of Open Datasets, Evaluation of Infrastructure Readiness for AVs and Automated Driving Safety Research
- Contributions from University collaborators from our ICRI in Europe on dependability of automated vehicles
- Contributions from our Government Collaborations such as EU Commission for Automated Driving
- Contributions from our collaborator Mario Trapp from Fraunhofer institute on safety-critical software
- Perspectives from government regulators in Australia and Singapore on developing a regulatory framework for the test and verification of AV's on public roads.

In addition to these paper contributions we will invite all the accepted authors to take part in a panel discussion moderated by the authors in which the public will have the possibility to address questions or propose challenges towards a joint efforts of solving the automated vehicle safety assurance challenge.

V. DISSEMINATION PLAN

Upon approval, we will consolidate plans for submission to the CFP within our collaborators.

We will also distribute the CFP of the special session across the wider research and industry and government communities using mailing lists, professional and research social networks as well as marketing tools from Intel Corporation.

We will also host a website with information on the Special Session that will also help disseminate any public material that results from it.

VI. CONTACT DETAILS



Maria Soledad Elli, joined Intel in 2017 as Data Scientist for the Automated Driving Path Finding team and since then she has been involved in several projects such as, AV workload analysis, AV simulation and AV Safety Standards. She obtained her masters degree in Data Science from Indiana University Bloomington in 2017, with strong focus on machine learning and computer vision applications. In 2013, she received her bachelors degree in Computer Engineering at the National University of Tucuman, Argentina. She worked until 2015 as

a Software Engineer at the Aerospace and Government Division at INVAP SE, one of the leading Latin American corporations in applied high-tech.

Address: 2111 NE 25th Ave, Hillsboro, Oregon, USA, 97124

Phone: +1-812-327-7911

Email: maria.elli@intel.com



Ignacio Alvarez, is a Senior Research Scientist at the Automated Driving Research Lab in Intel Labs. He obtained his PhD in Computer Science at University of the Basque Country, Spain and Clemson University, USA. A veteran in Automotive Industry, previous to Intel, Ignacio worked at BMW in the development of Connected Drive technology. His research interest focuses on the development of intelligent connected automated vehicles to provide secure and effective means of transportation empowering human potential for

safer and more enjoyable driving experiences.

Address: 2111 NE 25th Ave, Hillsboro, Oregon, USA, 97124

Phone: +1-971-223-9766

Email: ignacio.j.alvarez@intel.com



Jeffrey Ota, is a Sr. Principal Engineer at Intel Labs and leads research and development in autonomous driving, sports, and autonomous systems. His expertise is in utilizing computer vision and video as inputs into autonomous control systems. Prior to Intel, Jeff was a researcher at the NASA Ames Research Center (Mars robots), an Engineer-in-Residence at Santa Clara University (autonomous robotics), at the BMW Technology Office (driver assistance systems), NVIDIA (ADAS algorithms on the GPU), and Nike (ad-

vanced research).

Address: 2200 Mission College Boulevard, Santa Clara, CA 95054

Phone: +1-408-888-4410

Email: jeffrey.m.ota@intel.com



Jack Weast, is a Sr. Principal Engineer at Intel and VP Autonomous Vehicle Standards at Mobileye. In his nearly 20 year career at Intel, Jack has built a reputation as a change agent in new industries with significant technical contributions to a wide range of industry-first products and standards in complex heterogeneous high performance compute solutions in markets that are embracing high performance computing for the first time. With an End to End Systems perspective, Jack combines a unique blend of embedded product

experience with a knack for elegant Software and Systems design that will accelerate the adoption of Autonomous Driving. Jack is the co-author of UPnP: Design By Example, is an Adjunct Professor at Portland State University and is the holder of 23 patents with dozens pending.

Address: 5000 W Chandler Blvd, Chandler, Arizona, USA, 85226

Phone: +1-503-264-6084

Email: jack.weast@intel.com



Markus Maurer, studied Electrical Engineering at the Technical University of Munich (Diplom 1993). He then joined the group of Prof. E. D. Dickmanns at the Universität der Bundeswehr München where he finished his PhD in 2000 in the field of automated driving. From 1999 to 2007 Prof. Maurer was a project manager and head of the development department of "Driver Assistance Systems" at Audi. Since 2007 he has been a full professor for Automotive Electronics Systems at the Institute of Control Engineering at Technical

University of Braunschweig. His current research is focused on the inherent risk of autonomous vehicles.

Address: Hans-Sommer-Str. 66, 38106 Braunschweig, Germany

Phone: +49-(0)531-391-3840

Email: maurer@ifr.ing.tu-bs.de

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