EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-i08**
Version: 1.0

Title: Harmonised metrology for autonomous vehicle sensors

Abstract

Autonomous Vehicles (AV) and vehicles with Advanced Driver Assistance Systems (ADAS) rely upon perception sensors and algorithms for automated decision making to determine their environment. Reliance on these systems for safety critical applications means robust characterisation and uncertainty quantification of individual sensors, sensor networks and decision algorithms. Industry has acknowledged the importance of developing a set of common methodologies and definitions for characterising sensor performance under different conditions. This project aims to provide a standardised framework to facilitate the validation and deployment of AV / ADAS on roads in Europe to improve market potential and consumer confidence.

Keywords

Autonomous Vehicles (AV), Advanced Driver Assistance System (ADAS), Automatic Lane Keeping Systems (ALKS), Sensor Networks, Sensor models, Sensors Degradation, Uncertainty, Reliability, Synchronisation, Calibration

Background to the Metrological Challenges

Autonomous Vehicles (AV) and/or vehicles with Advanced Driver Assistance Systems (ADAS) are starting to be deployed in the market for a range of applications: from agriculture to domestic transport. Several different perception sensors determine the vehicle’s physical environment and the position of other road users. Sensor performance is affected by road technologies, weather conditions and other environmental factors, such as dust and vibration. Understanding the characteristics and reliability of sensor performance and detection limits is safety critical, thus establishing harmonised metrics and test methodologies is vital.

An increasing number of sensor models are coming to market at a range of sensitivities, reliabilities and cost. Whilst establishing accurate, low-cost, low-power consuming sensors (such as digital microelectromechanical system sensors) would have undoubted advantages, poor sensor data may need to be addressed through intelligent algorithms. Hence, reliable metrics need to be established to understand the impact of poor data quality. However, the testing of sensors and fused systems is not yet standardised. Component level descriptions of performance criteria exist, but do not represent the actual needs for of such complex in-field applications and typically do not include the sensor fusion.

Virtual and physical simulation of automated driving functions is the only practical way to assess the myriad of scenarios that may comprise the performance of a sensor device, perception system and control algorithm design verification plan. Computer models of sensors need to accurately represent its behaviour under all relevant circumstances, including poor weather. Physical simulation of driving scenarios should recreate equivalent environmental conditions and be able to do so on a repeatable basis for validation purposes. As such, it is important to design reference facilities and test procedures to evaluate sensor performance under controlled normal and adverse conditions. Additionally, it is necessary to define perception limits (weather, lighting) to evaluate the ADAS sensors benefit.

The American Automobile Association (AAA) conducted a series of tests using vehicles with automatic emergency braking and pedestrian detection alerts on a closed course with dummy pedestrians. The vehicles struck the dummy pedestrians 60 %, in daylight conditions and speeds of 20 mph. When adult dummies were replaced with child-sized versions the results deteriorated and a collision occurred 89 % of the time. In order to boost public confidence in the safety of such vehicles, it is crucial to develop a common approach to sensor performance testing. Cases with human casualties where system failed to recognise other road users due to high and low contrast, highlighted the need for evaluation of fused sensor system and the algorithm performance for the given application conditions.

Traditionally, driving has been a human visual task and therefore performance metrics are based on human needs: a red traffic light as well as a yellow road marking have a clear and different meaning and implies different driver behaviours from a green traffic light or white road marking. AV/ADAS sensors not only need to perceive and adapt to the environment, but ideally perform better than a human. Currently their classification is based purely on the performance of an individual components' technical specifications. These exclude specific environments and applications related to performance and the associated uncertainties and tolerances are not considered when installed in current ADAS. In particular, the data quality and sensor degradation are not accounted for in the assessment of algorithm performance.

Many standards organisations have contributed to the development of a wide ecosystem, e.g. through ISO, BSI, IEEE, and private consortia, to facilitate the safe deployment of AV/ADAS but these are rather high-level guidance documents, not based on metrological good practice.

Significant gaps remain in the determination of sensor and Artificial Intelligence/Machine Learning (AI/ML) performance, particularly in relation to the fusion and synchronisation of data for disparate sensors; the development of robust and accurate sensor models; and simulators providing accurate electromagnetic representations across the spectrum. Therefore, there is a significant need to develop testing methodologies and facilities to validate the performance and limitations of ADAS/AV perception systems, specifically given existing capabilities cater for the functional test of the whole vehicle in limited scenarios.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on robust characterisation and uncertainty quantification of individual sensors, sensor networks and decision algorithms.

The specific objectives are

1. To establish traceability and fault-finding mechanisms for robust modelling frameworks and sensor data, e.g. for sensors integrated in radars, cameras, lidar, GNSS/positioning, dynamic displacement, accelerometers and gyroscopes. The traceability chain will include physical testing of sensors, emulated tests of sensors using phantoms and virtual test environments.
2. To characterise sensors and the algorithm fusing the sensor data and to investigate physical ageing and degradation of the sensors, taking into account environmental factors such as thermal and vibrational cycling.
3. To develop metrology tools and methods to characterise the fusion of sensors and to perform simulations of robust sensor model deployment. These simulations should be validated through the characterisation of physical sensors. In addition, to define testing reference conditions based on real applications and conformity criteria.
4. To determine the reliability of Machine Learning (ML) control algorithms for Autonomous Vehicles/Advanced Driver Assistance Systems (AV/ADAS) This will include investigation of e.g. accuracy, uncertainty propagation, synchronisation of systems, and the impact of cloud-based processing vs. edge computing via wireless networks.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (calibration laboratories, NMIs, DIs), standards developing organisations (IEEE, ETSI, UN ECE) and end users (automotive industry).

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.5 M€, and has defined an upper limit of 1.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the automotive sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”.

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.