Precision and Availability Evaluation for Road and Rail Localisation Platforms

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Abstract

New control systems for automotive and railway applications often use position information, which have been captured on board of the vehicle. This contribution shows an approach for the evaluation of the precision and the reliability of these localisation systems, based on a road-rail vehicle called Rail Driving Validation Environment (RailDriVE).

1 Introduction

The precise detection of the position plays a key roll for train operation control systems as well as next generation advanced driver assistance systems (ADAS). Especially for regional railway lines, which usually have a low traffic density, the positioning onboard of the trains is more cost-effective than having trackside equipment for localisation. A cost reduction may result, since only the onboard-positioning system has to be installed and maintained; maintenance of the numerous elements along the track (e.g. axle counters, track circuits) is no longer needed.

2 Automotive and Railway Applications

2.1 ADAS

Today, cars are supporting the driver in his driving tasks to improve traffic safety and fluidity. A driver who is aware of the situation, well informed about the traffic status and knows what he or she has to do is always the safest and best performing one. Advanced Driver Assistance Systems (ADAS) are implemented in cars to improve the situational awareness and to inform so that the general traffic safety and fluidity is enhanced. The first generation of driver assistance systems showed a defined but fixed functionality. If they were activated they always worked in the way, the driver has set them. The current and much more the next generation of ADAS have to act suitable for the driver, the traffic situation and the destiantion of the driver. The characteristic attributes of the driver are e.g. gender, age and driving experience.

2.2 Railway Control System

The precise detection of the position and the safe communication play a key roll for the train operation control system. Especially for regional railway lines, which usually have a low traffic density, the positioning onboard of the trains is more economic than having trackside equipment for localisation. A cost reduction may result, since only the onboard-positioning system has to be installed and maintained; maintenance of the many elements along the track (e.g. axle counters, track circuits) is no longer needed. Thus, the number of track-side elements needed for positioning can be reduced to a small number of positioning sensors at the few vehicles used on the regarded regional railway line.

The proposed positioning system determines the position of the vehicle independently from trackside equipment, e.g. beacons and tags. The new train-borne positioning system has to have at least the same accuracy, reliability, and availability as the track-side system used so far regardless of weather conditions. An autonomous positioning exclusively with GNSS (i.e. GPS, GLONASS or in the future GALILEO), as it is done for scheduling and logistics, cannot fulfil the requirements for safety-critical applications, such as track vacancy information. Hence, the GNSS-based positioning system has to be extended by at least one additional positioning principle to obtain redundant, diverse pieces of information. By fusing the positioning information of at least two systems a highly accurate, reliable and save positioning through onboard-equipment is possible. The transmission of the positioning data and the communication between the vehicle and the track-side is realized via GSM-R.

At the Institute of Transportation Systems of the DLR a vehicle-borne positioning system is currently being developed, which enables a track-selective positioning. An accuracy of up to 6 m (99%) lengthwise is assumed to be sufficient for regional lines with low or moderate volume of traffic. That means that the positioning system has to reach these values. A road-rail-vehicle, which is called Rail Driving Validation Environment RailDriVE, is used as positioning system laboratory and is equipped with a variety of positioning sensors, communication equipment and computer technology (see Figure 1) [1]. Table 1 gives an overview of the positioning sensors, which have already been installed or will be installed soon, and specifies their kinds of measurement variables.

The aim is testing of different combinations of sensors in order to identify suitable combinations, to fulfil the functional requirements and reduce cost. The combination of GNSS, eddy current sensor and digital map emerge as promising [2]. The prototype of the new eddy current sensor is, beside global satellite navigation systems, the only train-borne sensor which allows an absolute positioning. It will also be analysed if a combination of GNSS, digital map, odometer (incremental encoder, radar or optical sensor) and inertial system, which delivers the driving direction in angular degree, offers a sufficiently good position detection while the costs could be

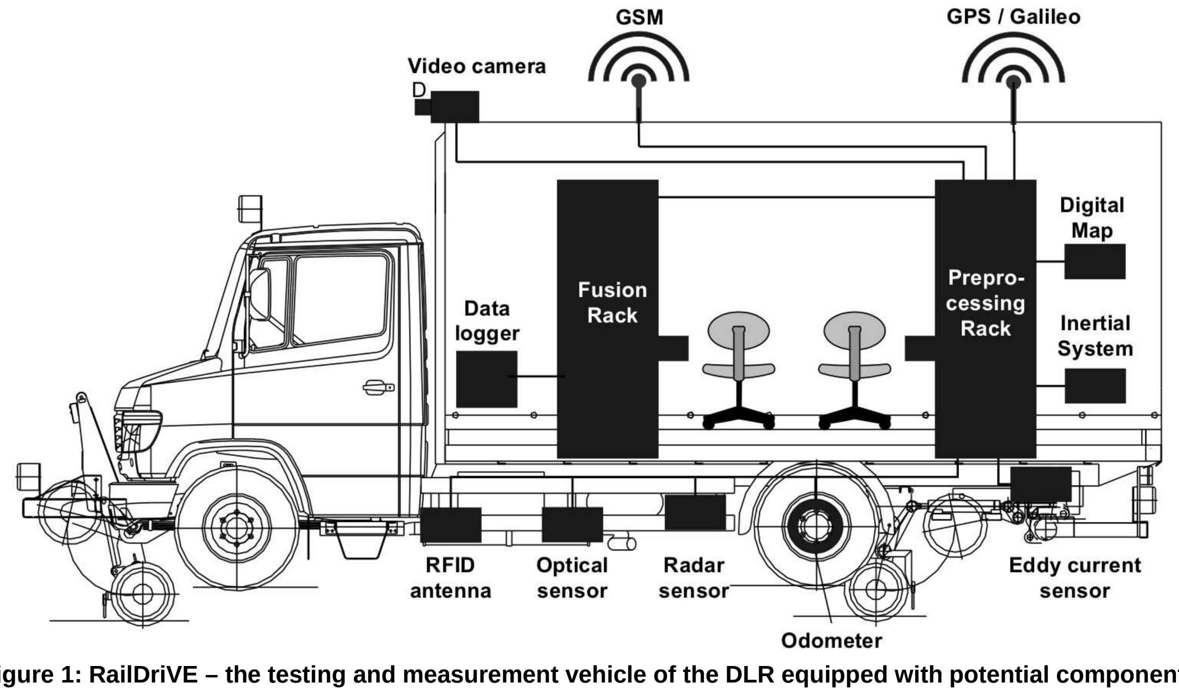

Figure 1: RailDriVE – the testing and measurement vehicle of the DLR equipped with potential components of a train-borne positioning system

Sensor	*Field of Application*	*Distance*	*Speed*	*Acceleration*	*Position*	*Standstill*	*Inclination*
Eddy Current Sensor	**Rail**	**X**	**X**			**X**	
Optical Odometer (Correvit)	**Rail (and Road)**	**X**	**X**			**X**	
Odometer (Incremental Encoder)	**Rail**	**X**	**X**			**(X)**	
RFID	**Rail (and Road)**				**X**		
Radar	**Rail (and Road)**	**X**	**X**				
Video	**Road and Rail**		**(X)**		**X**		
GNSS	**Road and Rail**	**(X)**	**X**		**X**	**(X)**	
Inertial System	**Road and Rail**		**X**	**X**			**(X)**
Inclination Sensor	**Road and Rail**						**X**

Table 1: Measured variables of the different positioning sensors

below those of the previous system. It also would have the advantage that it could be used both on the road and the track.

In addition to the positioning system itself, the RailDriVE will also contain a reference system. The RFID-antenna drawn in Figure 1 reads out the information which is sent out from the RFID-transponders laid in the track bed. In that way it can discretely determine the absolute position of the vehicle. In combination with a precise odometer the RFID-system, which is not purely vehicle-borne, will be used as the reference system.

Apart from the development of fusion algorithms for the various sensor combinations, map matching of the determined positions and the generation of digital maps of the testing areas are the important aspects when developing a vehicle-borne positioning system.

3 Conclusion and Perspective

For safety-critical positioning applications in the automotive as well as in the railway sector it is mandatory to guarantee a certain quality of the positioning result. With its special equipment the RailDriVE offers the possibility of evaluating the accuracy, availability and reliability of positioning systems.

It is planned to improve these three quality factors for the vehicle-borne positioning system of the RailDriVE by optimizing the data fusion algorithm e.g. by taking into account that some sensors do not work properly in certain environments, such as GNSS (Global Navigation Satellite System) in tunnels and most of the radars have problems with snow and ice.

References

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