DENSE

D3.1

System specification

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Document information

AUTHORS

Anders Cassel - ALS

Laurens Hobert - HIT SAS

Mario Bijelic - DAI

Hervé Illy - REN

Rosa Mario Vinella - XEN

Hanno Holzhüter - IBEO

Matti Kutila - VTT

Albert Manninen - VTT

Janne Häkli - VTT

Samuli Laukkanen - VAI

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CONTACT

Dr. Werner Ritter

Daimler AG

Wilhelm-Runge-Straße 12

89082 Ulm

Germany

Phone: +49 731 505 2140

Email: Werner.R.Ritter@Daimler.com

www.DENSE247.eu

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1 Summary

The present document, deliverable D3.1, provides the system specification of the DENSE all-weather perception system that aim to fulfil the overall system requirements described in deliverable D2.3.

The DENSE system aims to overcome the problem of limited perception capability in restricted visibility conditions. The concept boosts performance by merging elements of three different sensor types: (i) Shortwave Infrared (SWIR) gated camera sensor (ii) SWIR LIDAR and (iii) radar. The additional inclusion of road state sensing will allow assessment of road surface conditions. The information of these sensors is then combined via a Deep Neural Networks (DNN) to efficiently fuse information from the various sensors.

The aim of the DENSE project to achieve higher detection ability in adverse weather rests on the ability of DNN-based algorithms to extract useful information from several sensors even if their outputs are degraded due to the adverse weather conditions. Having more than two sensors also means that a level of robustness and fault tolerance can be achieved even if data from one sensor is lost due to faults, obstructions, or other reasons. However, that also means that an ultimate system will need to have overlapping sensing areas for the involved sensors.

For timing and financial reasons, the sensors in the prototype installation will not fully comply with the ultimate specifications in all aspects, but are selected to achieve a reasonable system demonstrator to prove the viability of the sensor suite in combination with the DNN to achieve the increased performance in adverse weather conditions. The present document specifies the requirements of the demonstrator system. The implemented demonstrator will therefore have some limitations mainly on system field of view and some system aspects such as ultimate user interface and vehicle integration in a targeted vehicle which will be referred to the serial development phase.

The SWIR gated camera sensor is an optical sensor which offers resolution and multi-purpose abilities in a similar fashion as visual cameras do, but with better range when the atmosphere contains obscurants such as rain, fog and snow due to the longer wavelength. However, conventional continuous illumination offers limited benefits due to the back-scatter from the obscurants in the atmosphere (compare with driving with high-beam in fog). Adding pulsed illuminations and gated cameras allow for filtering away backscatter which is outside the range of interest. The camera will only receive light during a short gate, at specific times. Due to the fact that the emitted illumination pulse has travelled a certain distance when the camera gate is opened an image is formed only from object that are located at that distance. An image of a slice of the scene is taken. By combining several of such image slices a complete 3D image can be sampled eliminating most of the blinding effect otherwise caused by undesired backscatter.

LIDAR utilizes another more direct approach to the time of flight principle. Short light pulses are emitted by a source. Usually a laser is used to generate these pulses. An optical receiver collects eventually light reflected by an object. The time between emitting and receiving a pulse is measured. Assuming a constant

speed of light the distance between LIDAR sensor and object can be calculated from this time. Usually only a discrete point in the scene is illuminated, thus providing a 1D Measurement. To expand the field of view into 2D or even 3D usually a scanning apparatus is used. By doing this a detailed distance map from the sensor's environment can be generated.

Radar is another sensor for measuring distances. It utilizes a measurement principle similar to LIDAR but also generates a velocity reading of the detected object due to the Doppler Effect. The longer wavelengths (~5000 times longer than visible light) allow good penetration in an atmosphere obscured by comparatively small particles like fog. However, the radar's lack of lateral resolution implies limitations to its ability to accurately classify objects that have been detected. We will explore a new type of radar utilizing multiple-input and multiple-output (MIMO) to enable higher lateral resolution.

Combined, the involved sensors contribute with reasonable orthogonal sensing characteristics that will be affected differently by adverse weather. A clever integration using DNNs enable a combined performance that aims to significantly outperform the classification each sensor type would allow individually.