UP-Drive

Automated Urban Parking and Driving

Research and Innovation Action - Horizon 2020
Grant Agreement Number 688652
Start date of the project: 01-01-2016, Duration: 48 months

Deliverable D 2.4

Second vehicle platform fully operational

Status: Revision 1.0

Lead contractor for this deliverable: VW
Due date of deliverable: 30.04.2018
Coordinator: VW

Project co-funded by the European Commission within HORIZON 2020		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
SEAM	Restricted to partners of the SEAM Cluster (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Executive Summary

This deliverable documents the functionality of the second vehicle platform. Since the vehicle is a copy/paste of the first vehicle platform, in this report we thoroughly analyze only the upgrades and differences in the setup. The sensor system, computer system, communication system (in-vehicle and between vehicles) as well as HMI and safety elements are fully integrated, functional and thus fulfill the UP-DRIVE project requirements.

Contributing Partners

	Company/Organisation	Name
Document Manager	VW	Wojciech Derendarz
Partner 1	VW	Jens Spehr

Contents

1 Sensor data integrity validation

1.1 Vehicle Platform and updated sensor setup

The second test vehicle platform "Superwolle"' is based on the updated version of the fully electric VW e-Golf. The vehicle is a mirror version of the hardware and software of the first vehicle platform with upgrades of the LiDAR (32-layer LiDAR), two additional 4-layer LiDARs mounted on the front bumper, tri-focal system and additional cameras. It is fully operational with all sub-components integrated, collecting valuable data for further improvement and algorithm developments. Since the vehicle is a copy/paste of the first vehicle platform, in this report we will outline only the upgrades and differences in the setup and related sensor data integration. In Figure 1 both vehicle platforms are shown for comparison.

Figure 1: Second vehicle platform Superwolle (left) and first vehicle platform (right).

UP-Drive vehicle collects the following sensor data:

- 360° laser scanners: point clouds
- 4 layer laser scanners: point clouds
- Long range radar: objects and clusters
- Short range radars: clusters
- TopView cameras: images
- Trifocal camera: images and objects and other semantic data like traffic lights
- Odometry: relative vehicle motion
- Consumer grade GPS: coarse position and orientation data
- Consumer grade IMU: relative vehicle motion
- Ground truth DGPS: full 6DOF position and motion data

The data availability, format and sensor data integrity validation have been already reported in Deliverable 2.1 and 2.2. Additionally, the sensor setup and the position of the individual sensors have been described in D2.3. Here we analyze only the integrity of the sensor data of the updated components.

1.2 Sensor measurements verification

1.2.1 Distance / 3D measurements

In this section the integrity of the 3D measurements of the updated sensor system components is analyzed. Since the vehicle is a mirror version of the hardware and software of the first vehicle platform, below we report the observation of the sensor upgrades LiDAR (32-layer LiDAR), supplementary 4L-scanners and the tri-focal system. The analysis has been performed by observation in real life scenarios and performing additional controlled experiments. For the rest of the sensors setup, it can be said that the sensors perform in accordance to specification, as described in D2.2.

360° laser scanners (32-layer LiDAR)

The Velodyne VLP-32 sensor is an advanced product in Velodyne's 3D LiDAR product range. The sensor uses 32 infra-red (IR) lasers paired with IR detectors to measure distances to objects up to 200 meter in 360° with surround view with real-time 3D data. It is a high-resolution sensor developed with automotive applications which combines long-range performance with 0.33 degree vertical resolution in a compact form factor. The difference in performance between 16- and 32-layer LiDAR can be seen in Fig. 2.

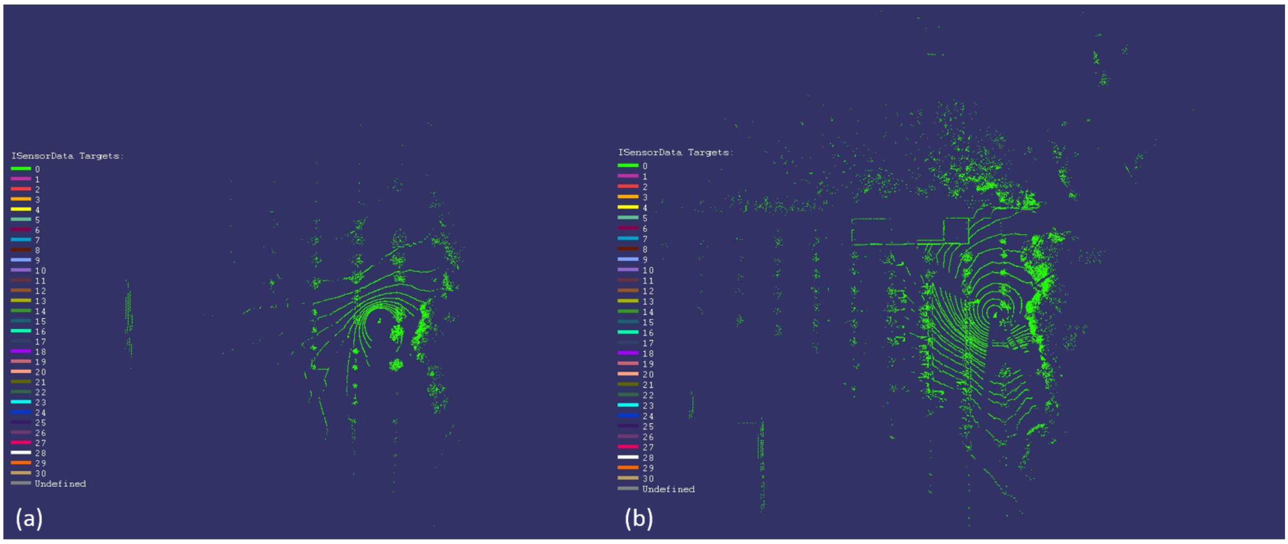

Figure 2: Performance comparison of Velodyne VLP16 (a) and VLP32 (b).

4-layer laser scanners

The sensors work in accordance to the specification. Range measurements are provided up to a distance of 150-200m. Unlike the 360° laser scanners, the vertical field of view of the 4L-scanners is only about 3°. In addition to the sensors mounted horizontally at the height of vehicle bumper, the second vehicle platform is equipped with two supplementary 4L-scanners mounted on the left and right side of the front bumper (see Fig. 1). Such configuration allows for very stable object detection - at least in situations where the ego-car is level and the road-surface is flat. Deviations from that ideal configuration can lead to substantial reduction of perceivable range. In total, six automotive 4L-laser scanners are installed (three at the front (one central + two skewed on the leftand right hand side), two lateral (left and right) and one at the back of the vehicle) thus generating a reliable 360° view of the vehicle's surroundings.

Trifocal camera

The second vehicle platform has been upgraded with novel trifocal-lensed system from Mobileye. The new camera provides improved depth perception & better distant-object detection. As shown in Fig. 3, it is placed in the upper part of the windscreen, is three cameras in one, providing a broad 150° view, a 46° view and a long-range narrow, 28° view for improved depth perception and distant-object detection. The camera can spot suddenly appearing pedestrians or other unexpected road hazards, thus significantly improving the perception system in complex urban scenarios. The sensor provides data for multiple required functions such as: road infrastructure detection (lane delimiters, arrow markings, stop lines, pedestrian crossings); object classification (cars, trucks, pedestrians, bicyclists, indicators, stop lights); traffic sign and light detection; 3D terrain perception (curb stones, generic road boundaries); free space grid construction. Functionalities of the the sensor has been extensively tested and validated to work according to the specification.

Figure 3: The new trifocal vision system integrated in the upper part of the windscreen.

Sekonix camera

Figure 4: The Sekonix 120° FOV camera vs Sekonix 60° FOV.

The Sekonix 60° GMSL camera mounted behind the windshield has been upgraded by its 120° equivalent. The field of view (FOV) is sufficiently wide assuring the coverage of the lane at the immediate front of the vehicle and of the adjacent ones, in order to assure the detections of the lines on the road pavement and the detection of objects and people at the side of the road even when at short distance from the vehicle. The difference in view between both cameras are shown in Fig. 4.

1.3 Calibration data and its verification

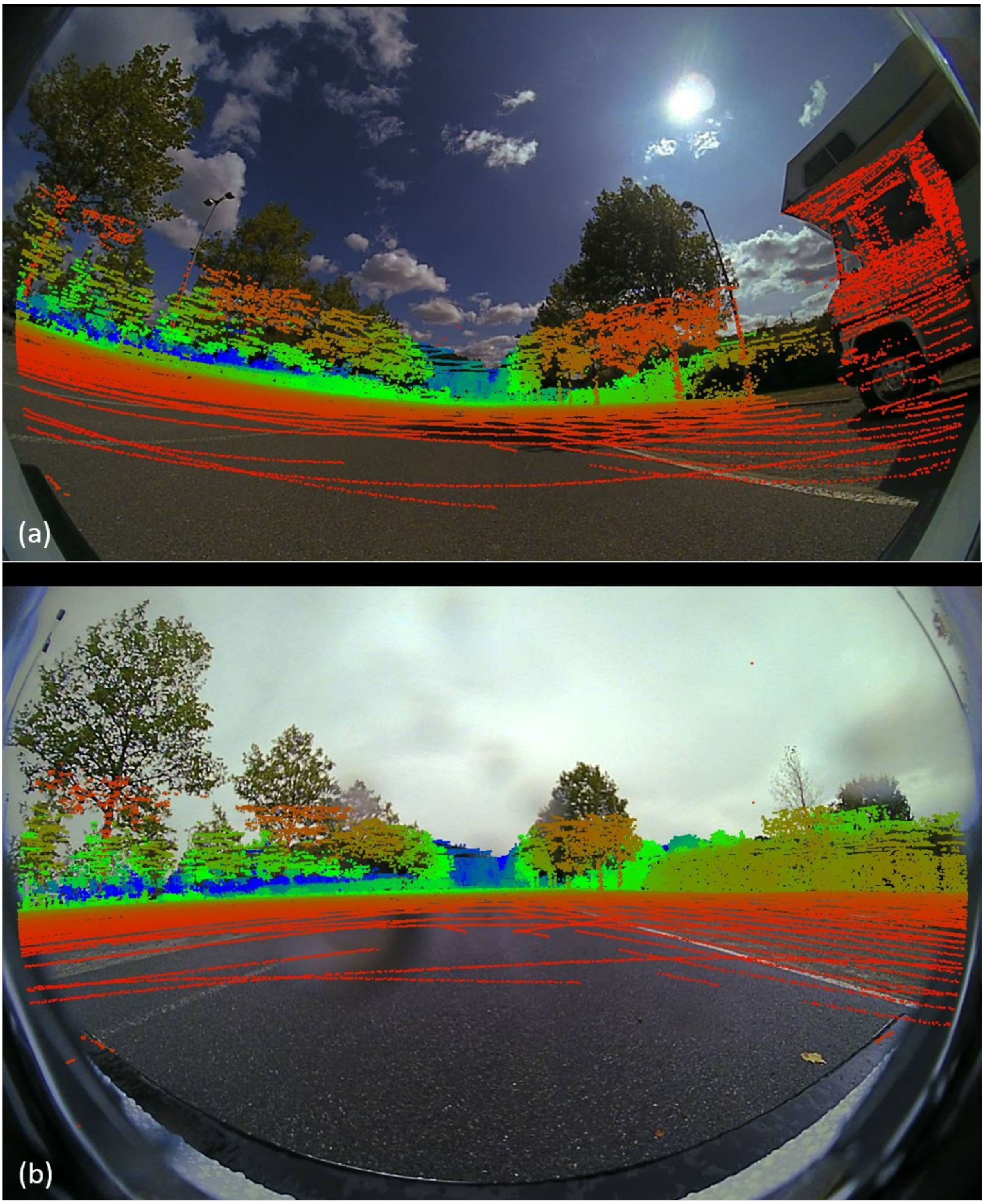

Figure 5: Comparison of calibration results: first (a) and second (b) vehicle platforms.

The sensor setup was calibrated using the CVUT calibration tooling. The results are accurate enough and comparable to those from the first vehicle platform. Qualitative results can be seen in Fig. 5, where the projection of the 3d point cloud into the camera image is shown. The shape of the 3d information is accurately aligned to the image.

2 Computing platform

Computer cluster of the second vehicle has been improved both in terms of number of general purpose PCs, as well as their performance:

- 12 general purpose PCs instead of 8 i that will host most of the software to be developed within UP-Drive, equipped with Intel Core i7 processors, each with 4 cores, operating at 2.6GHz
- 2 Nvidia GTX1070 GPUs integrated into two of the general purpose PCs, an embedded system from Nvidia incorporating GPUs, which will be used to host some image processing algorithms,
- ZotacPC: GTX1080
- 1x DrivePX2
- a dedicated prototyping system, which will be used to host vehicle control algorithms,
- 2 Gigabit Ethernet network switches,
- a monitor, a KVM switch and a keyboard with integrated touchpad.

The computers in the trunk of the vehicle - as well as some sensors - are connected by Gigabit Ethernet networks. Most important of those is the network spanning the general purpose PCs.

Additionally, a lean and modular construction has been integrated in the trunk and all bulky components eliminated. This solved the problem with the very dense packing of the components. Updated modular construction allows easy handling and HW-debugging.

Figure 6: Upgraded computer cluster

3 Conclusions

This document shows that the second test vehicle is fully operational and satisfies all the defined requirements. Given the fact that the architecture of the first car has proven to fulfill the requirements, the second car was built identical to the first. The second vehicle platform "Superwolle" was delayed by 6 months and completed in M30. As another vehicle from a different project was made available to the UP-Drive team, this delay had only a minor influence on UP-Drive. Superwolle has been extensively used for the development work in all relevant WPs and acquisition of datasets, thus serving the project as an additional data collection platform for the test and evaluation of the perception, localization & mapping and scene interpretation developed in WP4-7.