TrimBot2020 Deliverable D6.1

First integrated platform

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Dissemination: PU

Abstract: The first integrated platform is build to collect a first data set from the test garden and evaluate the sensors. It is based on a modified BOSCH Indego lawn mower with additional sensors for ground truth position tracking. Eight cameras from the EHTZ, and a Velodyne VLP16 lidar scanner are mounted on the platform to capture environment data. An embedded PC is also integrated into the vehicle to control it and record the sensor data.

Deliverable due: Month 9

1 Vehicle Base Setup

For the vehicle base a commercial lawn mower (BOSCH Indego) is used. It is extended by an aluminium frame to carry an additional power pack, several sensors and an embedded PC. The modified lawn mower with aluminium frame is shown in Figure 1. For the software integration the Robot Operating System (ROS) is used. Therefore, the lawn mower firmware is modified to enable a serial connection for the remote control of the vehicle. The `indego` ROS node handles this serial connection and provides the possibility to control the vehicle by the `cmd_vel` topic. The ROS standard packages `joy`[1] and `teleop_twist_joy`[2] are used to control the vehicle with a standard joypad. A more detailed description of the software architecture and the ROS integration with all interface (topics/messages) is given in the software architecture document[3]. The maximum speed of the vehicle with the expected payload is 1.0 m/s. However, a lower maximum speed can be adjusted in the launch file of the `indego` node.

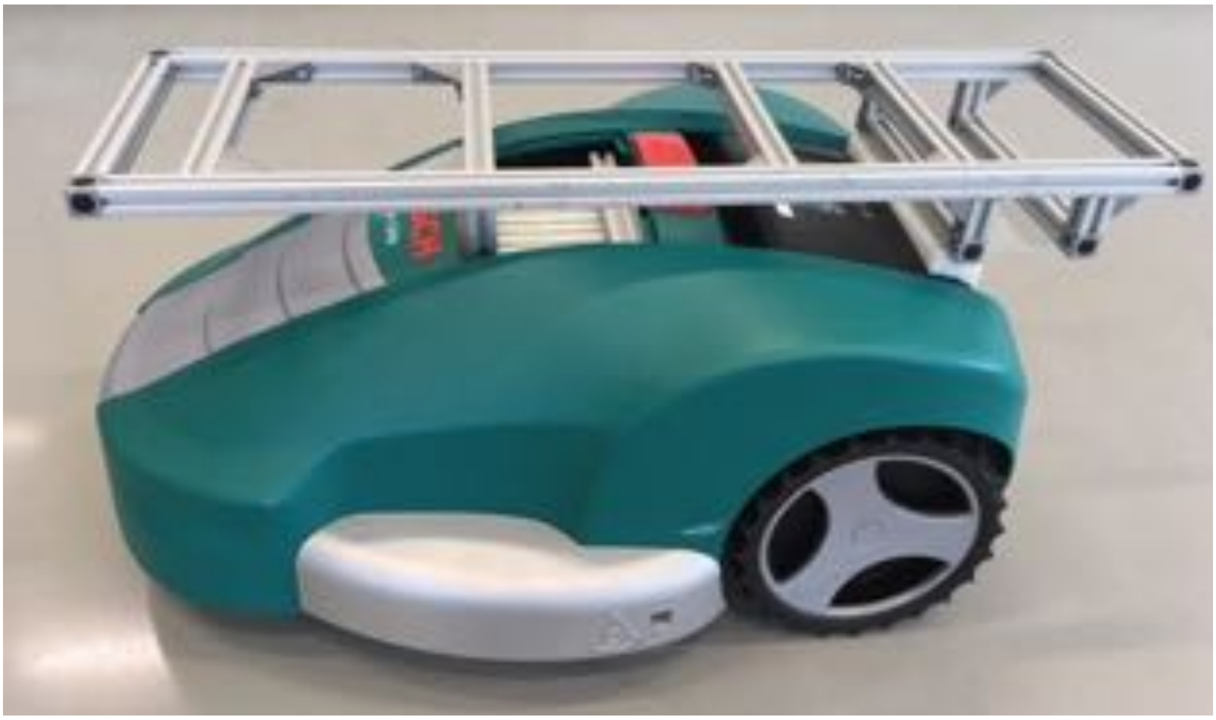

Figure 1: Aluminium frame for vehicle base.

2 Sensors

The vehicle base is equipped with several sensor for data collection including ground truth data. Therefore, eight cameras in an octagonal setup, a lidar sensor, an IMU sensor and a prism for a position tracking system are mounted on the aluminium frame. The integration of the lidar sensor, the IMU sensor and the prism was done by BOSCH in Renningen. The camera

[1]http://wiki.ros.org/joy
[2]http://wiki.ros.org/teleop_twist_joy
[3] https://gitlab.inf.ed.ac.uk/TrimBot2020/General/tree/master/architecture/software

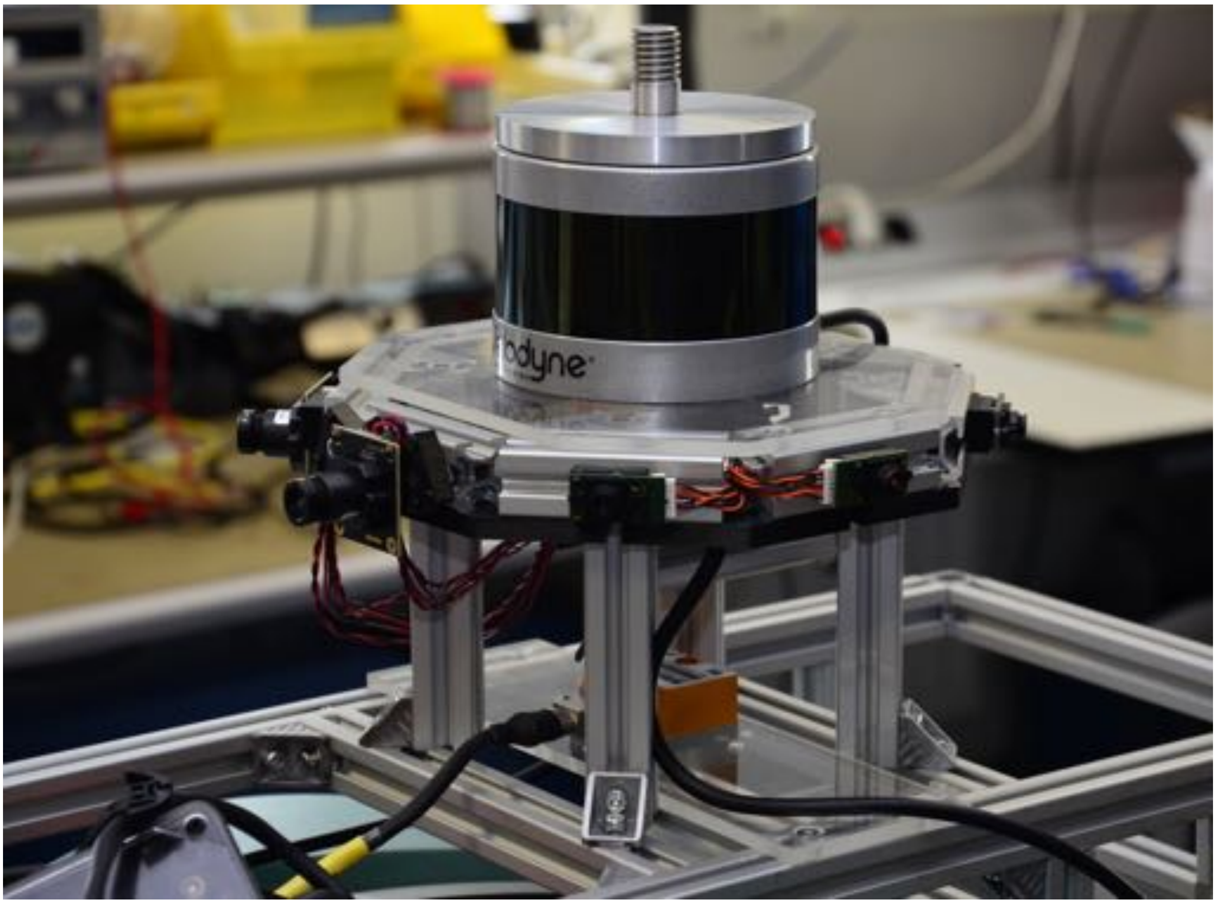

Figure 2: Cameras mounted on the vehicle with VLP16 on top.

integration was done during the first data recording session in Wageningen from 30. August 2016 to 1. September 2016 by BOSCH and ETHZ.

2.1 Vehicle Cameras

For the vehicle cameras an octagonal aluminium frame is placed on top of the vehicle frame as shown in Figure 2. Each camera has a Field of View (FoV) of about $55°$ thus the combined field of view is $360°$ with a small horizontal overlap of about 20%. This overlap is not satisfactory for stereo image processing and the lenses have to be replaced before the second data collection session to extend the overlap to about 50%. A schematic of the octagonal camera setup with lenses with a FoV of about $55°$ is shown in Figure 3. This setup is used for the first data collection session in Wageningen.

All eight cameras are connected to one FPGA. This FPGA provides the USB connection for all cameras. The connection to the FPGA is handled by the `uvc_camera` ROS node from the ETHZ. This node provide the images for all cameras and enables the image data recording with ROS. The camera setup includes six monochrome and two color cameras. The two color cameras are mounted at the front and front/right position (cam_6 and cam_7 in Figure 3). Each camera includes an IMU sensor. In this first setup only the IMU data of cam_0 is provided by the `uvc_camera` node.

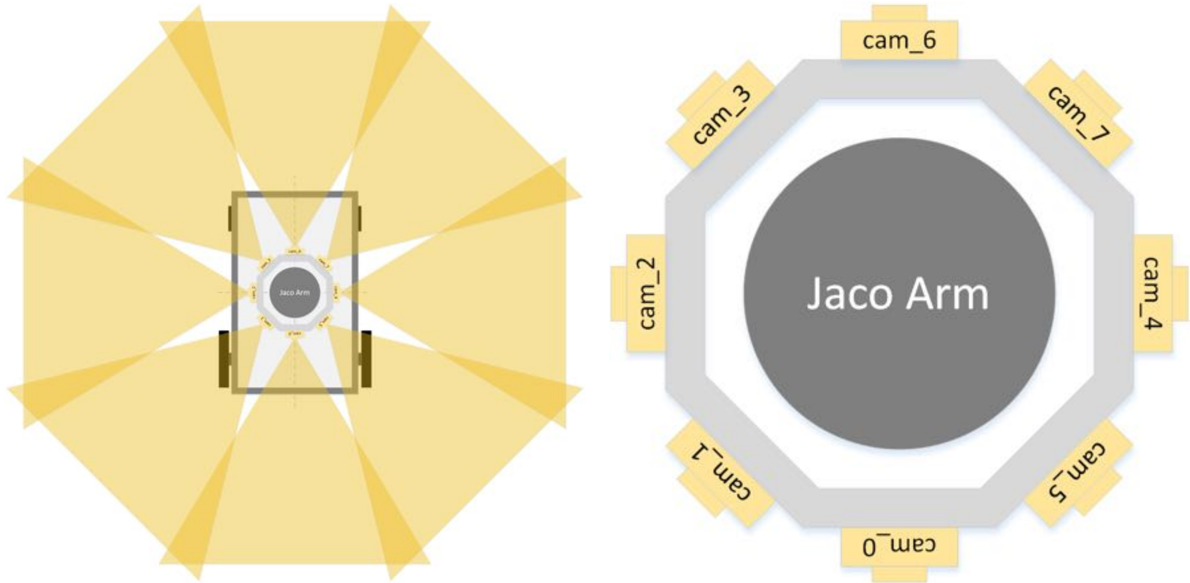

Figure 3: Schematic for an octagonal camera setup with FoV of about $55°$ per camera.

2.2 Lidar Sensor

The Velodyne VLP16 lidar sensor is mounted on top of the camera frame as shown in Figure 2. It is used to record a reference point cloud from a viewpoint close to the cameras. The VLP16 is a 360° lidar sensor with 16 horizontal rays and a scanning range of up to 100 m with an accuracy of ± 3 cm. The 16 horizontal rays give a vertical field of view of $30°$. The VLP16 is connected to the embedded PC over Ethernet. This connection is handled by the `velodyne` ROS node which provides for each scan a PointCloud2 ROS message.

2.3 Inertial Measurement Unit (IMU)

An IMU is mounted on the vehicle frame to measure the acceleration and rotation rate along the vehicle axis. Based on these measurements the orientation of the vehicle is estimated and merged with position measurements from the position tracking system to achieve a 6-DOF ground truth position. A STIM300 from Sensonor is used as IMU sensor. A detailed description and specification of the STIM300 IMU is given in the data sheet[4]. The STIM300 is mounted close to the centre of rotation to minimize the lever arms. Figure 4 shows the mounted STIM300. The connection to the embedded PC is USB and the `stim300_node` ROS node handles this connection and provides the IMU measurement data as ROS Imu message. This message contains only the acceleration and rotation rate measurements. During the data recording sessions these messages are recorded. The vehicle orientation is then calculated in an offline post-processing based on the recorded measurements.

[4]http://www.sensonor.com/media/99614/ts1524.r20%20datasheet%20stim300.pdf

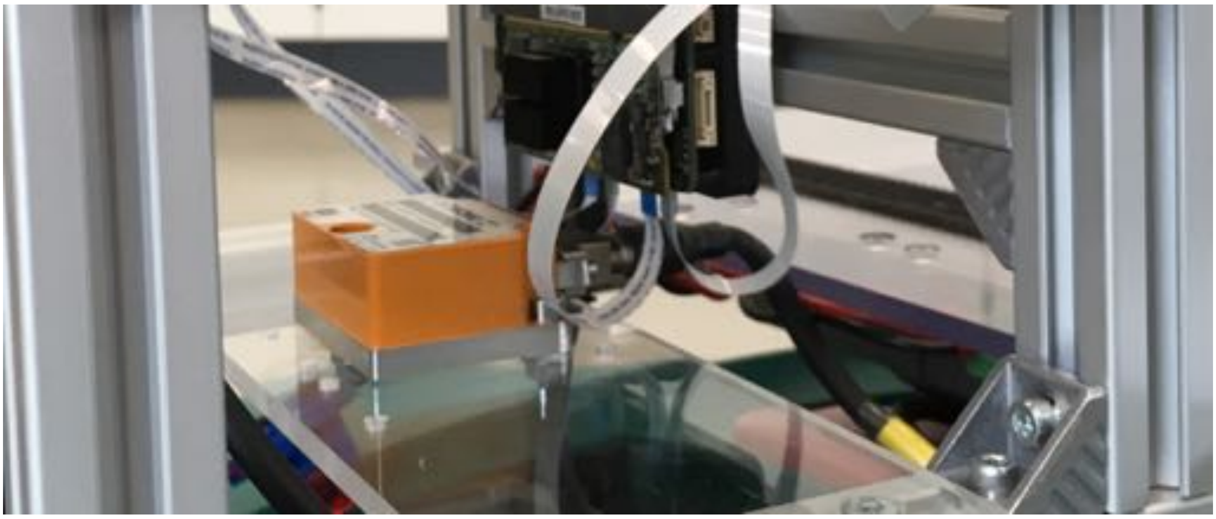

Figure 4: Stim300 IMU integration.

3 Embedded PC

For the first integrated platform a Pokini I2 embedded PC is used to control the vehicle and record all the sensor data. The Pokini I2 has an Intel Core i7-4600U (Haswell) processor and 16GB of RAM. It includes two hard disk. A 256 Gb mSata for the operating system and a 2Tb SSD for the data recording. The interfaces are two GbE LAN adapter, four USB 3.0 and two USB 2.0 ports. Due to this amount of interfaces all sensors can be connected direct to the Pokini. The vehicle base, cameras, IMU and joypad via USB and the lidar sensor via Ethernet. Figure 5 shows the Pokini mounted on the vehicle base. A remote laptop is used to setup a ssh connection to the Pokini via Wifi. This enables the login on the Pokini from the remote laptop.

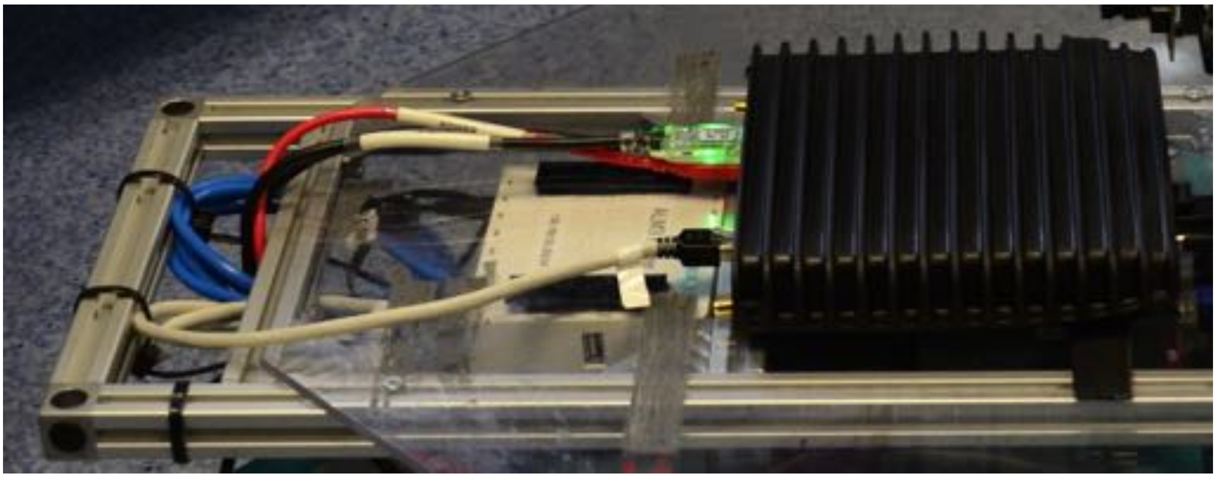

Figure 5: Embedded PC integration.

4 Position Tracking Prism

For the ground truth position estimation a Topcon total station is used to track and measure the distance to the vehicle. For the position tracking mode the total station needs a prism on the vehicle. Between this prism and the Topcon total station a line of sight is needed for the distance measurements. Therefore the prism is mounted on top of the Velodyne VLP16 lidar sensor. An example for the position tracking with prism is shown in Figure 6. The Topcon Total Station is placed on a tripod and connected to a remote laptop. The measurements from the position tracking are recorded on the remote laptop, thus the prism is the only part from the position tracking which is on the vehicle. The tracked position data is merged with the other recorded data in an offline post-processing step into one data set.

Figure 6: Position tracking prism.

5 Integrated Platform

An image from the first integrated platform with all sensors and the embedded PC is shown in Figure 7. This platform is used for the first data collection session in Wageningen from 30. August 2016 to 1. September 2016. A detailed description of this data recording session is given in D1.1.

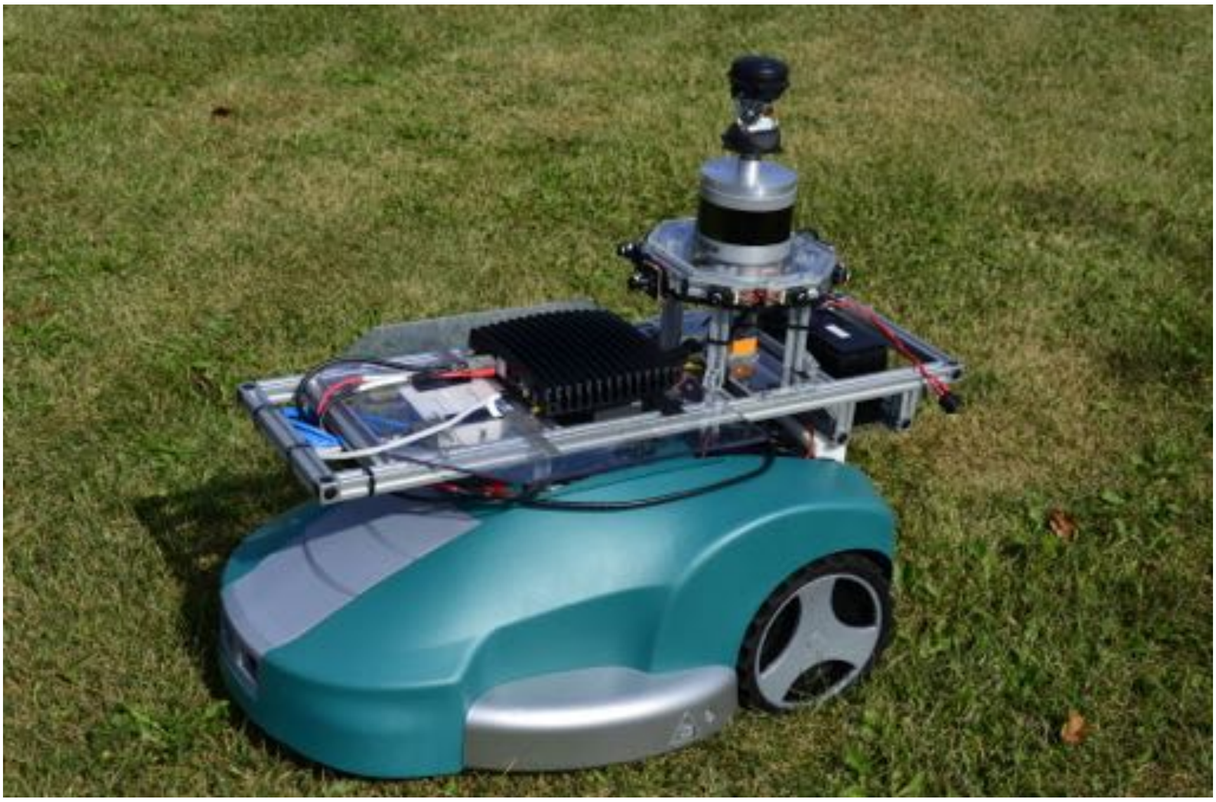

Figure 7: First integrated platform.

