Localization in orchards using Extended Kalman Filter for sensor-fusion - A FroboMind component.

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Making an automated vehicle navigate in rows of orchards is a feature, relevant for automating the plant nursing and cultivation of the trees. To be able to navigate accurate and reliably, the vehicle must know its position relative to the trees in the orchards.

Figure 1: Tractor used for collecting data in the orchard, with the orchard in the background.

The area of the orchard that the vehicle must move trough, can be split up in 2 parts[2]:

- Movements between rows of plants trees
- Turning from one row to the next, in area at the ends of a planted field (Headland)

Commonly RTK-GPS (Real Time Kinematic - Global Positioning System) is used for localization in outdoor environments, since it can be used globally and provide position accuracy within centimeters. This solution will encounter problem when moving near tall trees and buildings, since precision can be degraded from multi-path GPS signals. Futhermore a complete map of the orchard is needed.

Therefore it is relevant to implement other sensor options. Sensors like laser-range scanner (LIDAR), IMU(Initial Measurement Unit) and odometry, could also be used to determine the position and orientation (pose) of the vehicle, but they only work locally or suffers from accumulations of errors.. An example localization inside an orchard without using GPS, can be found in [7].

Figure 2: Placement of the IMU, LIDAR and Encoders on the tractor

The different sensors that can be used for pose estimation fall into different categories. IMU and GPS are global sensors, which provides relative and absolute data respectively. A laser-range scanner is a local sensor that provides positioning data of the surrounding objects relative to its own position. By fusing sensor data from different sensors (local and global) a good estimate of the vehicle pose (localization) can be obtained. The final solution is made into a component in the FroboMind architecture[5], that are implemted in ROS [6], so it can be can be used for real-time navigation in orchards.

In this project, each tree inside the orchard was used as an reference point, to ensure that the errors in the position estimates, will not increase significantly over time. Each tree is detected using a segmentation and tree detection method, developed for this project. The detection process can be seen in figure 3,4(a),4(b), where the detected trees can be seen in figure 4(b). The method is based on [1], [3], [4] and [8] for different parts of the process.

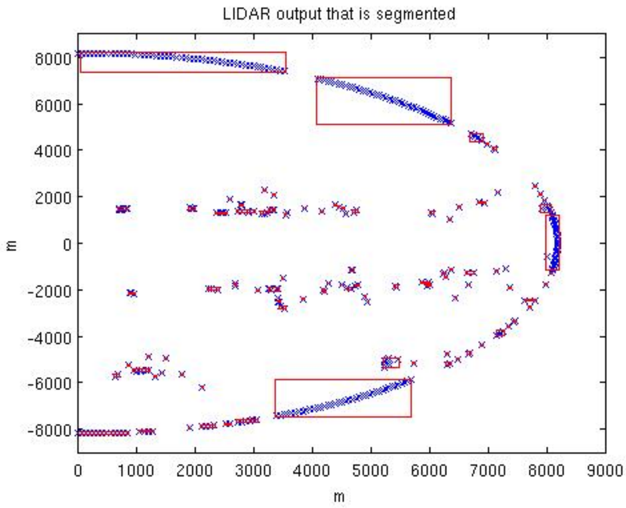
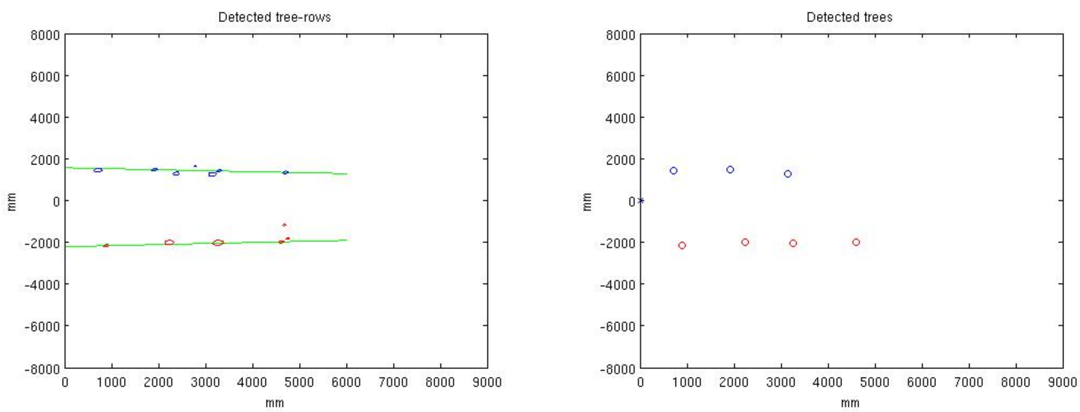


Figure 3: Example of LIDAR-data collected of from the orchard (blue dots). Red box's represent the segments that have be determined in the data



(a) Detection of tree-rows based on the segmented LIDAR-data

(b) The detected tree's selected from tree-candidates in the detected rows

Figure 4: Processing of the segmented LIDAR data to detect the surrounding tree's

Using the detected trees seen in figure 4(b) a localised SLAM map of the surroundings area, can be created an used to determine the localisation of the tractor. This kind of sensor-fusion is used, to keep the amount of prior information about outlay of the orchard to a minimum, so it can be used in orchards with different outlays of the trees.

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